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OFFSHORING, RESHORING, UNEMPLOYMENT, AND WAGE DYNAMICS IN A TWO-COUNTRY EVOLUTIONARY MODEL

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In this paper, the location patterns of Multinational Enterprises are modeled by an evolutionary two-country model in which producing in a developed economy offers strong cost-reducing externalities of within-country spillovers and opting for a developing economy entails cheap labor but also extra operational costs due to the undersupply of public goods. The offshoring process, that is, manufacturing activity outsourced in the developing economy, increases the bargaining power of its workers and, with it, its labor cost. The investigation underlines that an increasing labor-productivity remuneration in the developing economy may spark a reshoring process that depends on the agglomeration and endowment drivers characterizing an industry. The reshoring process can be narrowed by a flexible labor remuneration scheme, with wages indexed to the domestic concentration of manufacturing activity. The presence of sub-optimal location patterns points out the existence of a trade-off between stability and efficiency, which underlines that policy measures designed to make a country a more efficient location are neither sufficient nor necessary for preventing offshoring or ensuring reshoring.

Keywords: Manufacturing Location, Offshoring and Reshoring, Cost-reducing Externalities, Labor Policies, Industrial Policies, Nonlinear Evolutionary Model

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1. INTRODUCTION

Multinational Enterprises (MNEs) often offshore their manufacturing activities in developing economies seeking for advantages offered by cheap labor costs and lenient legislations. As a consequence of offshoring, a developed economy, such as a technological-leader country with high labor costs, may undergo relevant issues such as unemployment, reorganization of industrial activity, and deregulation of the labor market. To counteract the phenomenon, developed economies have focused on implementing policy measures designed to reduce job losses by providing incentives for MNEs to reshore their manufacturing activities. These incentive schemes, as well as the increasing salaries in the developing economies, have incentivized MNEs to bring back home some of their manufacturing activity. This reshoring process is however sluggish as suggested by empirical evidence [see Backer et al. (2016)].

The geographic distribution of industrial activity has attracted the attention of scholars. In particular, the *new economic geography* (NEG), originated by the seminal contribution in Krugman (1991), explains the distribution of economic activities between two identical regions and is able to explain various patterns, ranging from uniform distribution to spatial concentration of economic activities. Typically, the NEG framework is based on imperfect competition with increasing returns to scale, factor mobility, presence of trade, and transportation costs.

In this paper, we modify the point of view, by focusing more on the impact of manufacturing costs on the offshoring and reshoring process. The literature on International Business identifies two classes of factors that impact the location choices, the agglomeration drivers and the endowment drivers [see Alcácer et al. (2013)]. Endowment drivers are location traits such as physical infrastructure, quality of the labor force, cultural distance, or other public goods that enhance industrial productivity [see, e.g., Coughlin et al. (1991) and Flores and Aguilera (2007)]. Agglomeration drivers account for positive externalities that are derived from the geographical clustering of manufacturing activities, for example, due to technological spillovers, access to specialized labor, and access to specialized intermediate inputs [see Marshall (1892)]. Then, according to this approach, the presence of knowledge spillovers is country specific but also depends on the location choice of firms. These agglomeration economies have been studied with formal models [see Krugman (1991) and Bischi et al. (2003*b*)] and empirically documented [see, e.g., Carlton (1983) and Mariotti et al. (2010)].

Following this stream of research, in Bischi et al. (2018), manufacturing location patterns are described by a dynamic model that combines together endowment drivers and agglomeration drivers for the first time. It is an evolutionary model, based on replicator dynamics, that describes the location patterns of a manufacturing activity which is originally located in a technological-leader country. MNEs can decide to offshore in a technological-laggard country their production or part of it. In this two-country framework, the technological-leader country offers internal spillovers advantages, while the technological-laggard country provides cheap workforce, whose convenience, however, may be offset by lower labor productivity and extra operational costs due to the undersupply of public goods. The location decisions of MNEs are updated at discrete-time periods and are based on comparative production-cost advantages in the two countries that depend on four parameters: wages, within-country spillovers, nearby-country spillovers, and extra operational costs (only in the technological-laggard country).

In summary, the model in Bischi et al. (2018) is developed to describe the offshoring of manufacturing activity by MNEs, operated to take advantage of lower-cost workers only. We may think of the European automotive industry that (to satisfy the European Single Market) decentralizes the manufacturing activity in the Eastern Europe; for the sole purpose of enjoying lower labor costs. In this respect, this model describes a geographic decentralization process different from the one considered in the NEG literature, where location patterns are market-demand driven, with MNEs that decentralize their production to enter new regional markets with the aim of exploiting local demand and production factors. The diversity in the economic issue at stake justifies the differences between the two modeling frameworks. The one proposed in Bischi et al. (2018) is a partial equilibrium model; manufactured goods are sold in a single common market and only supply-side factors drive the location pattern. In these aspects, the modeling setup in Bischi et al. (2018) is similar to the one in Maurer and Walz (2002), where two regional governments compete (providing local infrastructures) to attract two mobile oligopolistic firms. On the contrary, the NEG models are general equilibrium models, heterogeneous local markets are considered, and market demands as well as remuneration of productive factors guide the capital mobility; see the Core Periphery model in Trionfetti (1997), the original Krugman's framework developed in Krugman (1991), as well as the recent variants such as the Vertical-Linkages version of the Core Periphery model in Trionfetti (2001), the Footloose Capital model in Martin and Rogers (1995), and the Footloose Entrepreneur model in Brakman et al. (2008). Despite these differences, similarities between the two approaches are present. In Bischi et al. (2018) the spatial distribution of the manufacturing activity is modeled according to evolutionary game theory (with a discrete time specification to account for delays in firms reallocations) as in recent NEG models [see, e.g., Agliari et al. (2014) and Commendatore et al. (2014)]. The setup in Bischi et al. (2018) accounts for heterogeneous endowment drivers in terms of public goods among countries that reflect in different transportation costs as well as manufacturing costs. These are important aspects that aslo the NEG literature considers more and more, see, for example, Oates (1995), Martin and Rogers (1995), Keen and Marchand (1997), Ihara (2008), and Cohen and Paul (2004). In addition, recent NEG models, see, for example, Brakman et al. (2008) and Commendatore et al. (2008), discuss also demand effects as well as fiscal effects of productivity enhancing public investments. Considering a partial equilibrium model, these later two aspects are neglected in Bischi et al. (2018). In addition, in Bischi et al. (2018), capital is mobile and can be transferred between countries as in the NEG models. Creation and leakages of knowledge spillovers are instead considered in Bischi et al. (2018) and neglected in the NEG models.

The concentration of the manufacturing activity in a country increases the (individual and collective) bargaining power of workers, which mirrors in higher salaries and, in the long run, can erode the initial cost advantage of offshoring. Inspired by this fact, in this paper, we extend the model in Bischi et al. (2018) by considering asymmetric labor-productivity remunerations and a bargaining power of labors/unions that changes dynamically as a consequence of offshoring and reshoring, see, for example, Ranjan (2013), with consequent dynamic minimum wages. Specifically, labor cost in either country increases as its domestic production increases, due to a higher labor demand that increases the salaries as well as to the action of workers' unions. This is an example of the so-called agglomeration disadvantages, see, for example, Maurer and Walz (2002) for the wage effect of agglomeration on manufacturing activity.

The derivation of the model is also different: in Bischi et al. (2018) the focus is on the cost functions, whereas the present contribution deals with the offshoring and reshoring processes determined by heterogeneous labor policies. The alternative derivation of the model allows us to investigate how the possible location patterns of the manufacturing activity impact the employment rate as well as the level of salaries in each country. At the same time, it offers a game-theoretical framework where higher technological spillovers and higher quality of the domestic infrastructure increase the attractiveness of a technological-leader country. This modeling framework can be used for investigating and for testing policy measures aimed at influencing the location choice of MNEs as well as the domestic employment rate and the domestic labor wages. The focus is on heterogeneous labor policies, such as asymmetric labor-productivity remuneration and increasing workers' individual and collective bargaining power, and how they affect offshoring and reshoring.

The investigation underlines that increasing labor costs in the technological-laggard country reduces its attractiveness and may spark a reshoring process. Times and methods of this reshoring process depend on the combination of agglomeration drivers and endowment drivers characterizing an industry. Abrupt changes from offshoring to reshoring, gradual reshoring, as well as coexisting location patterns of manufacturing are alternative configurations that are possible when the cost advantage offered by the technological-laggard country is eroded by increasing labor costs. Agglomeration drivers and endowment drivers impact on the effects of economic policy measures aimed at influencing the location choices of MNEs as well, which therefore need to be tailored to the peculiarity of each single industry in order to be efficient. The investigation reveals also that increasing labor costs in the technological-laggard country does not necessarily imply reshoring. For example, a flexible wage policy, such as minimum wages in the technological-laggard country that pace with the domestic concentration of the manufacturing activity, does not necessary imply reshoring. These results are confirmed by the empirical data, which show a sluggish reshoring process despite increasing labor costs in developing economies [see, e.g., Backer et al. (2016)]. The reshoring process can even be hampered by *spiteful behaviors* of MNEs, which underline that policy measures aimed at making the technological-leader country [the technological-laggard country] the most efficient location for manufacturing are neither sufficient nor necessary for avoiding offshoring [reshoring]. These later results point out the existence of a trade-off between stability and efficiency of location choices, with MNEs selecting sub-optimal locations.

The paper is structured as follows. Section 2 introduces the model. Section 3 contains the main results concerning the dynamics of offshoring and reshoring, showing transition paths from offshoring to reshoring as the labor wages, in the forms of labor-productivity remuneration and collective/individual bargaining power remuneration, vary. The focus is on the impact of domestic labor policies on the reshoring process. Section 4 underlines the possible trade-off between asymptotic stability and efficiency of location patterns such as reshoring and offshoring. Attention is paid to the learning mechanisms leading to sub-optimal location choices, the related economic consequences in terms of employment, wages, and offshoring, and the related implications in terms of labor policies. Section 5 concludes.

2. SETUP OF THE MODEL

Let us consider a *representative firm* that manufactures a commodity and two possible production locations (countries) indexed by $i = 1, 2$. The entire production of the commodity is sold in a common market at a positive price P according to a given demand function. Let us normalize to one the total industrial production. The representative firm chooses whether to produce in country 1 (domestic or developed country and technological leader) or to offshore a part of its production in country 2 (foreign or developing country and technological laggard). At each discrete time $t \in \mathbb{N}$ (e.g. every year), the representative firm decides to manufacture the fraction $x(t) \in [0, 1]$ of its overall production in country 1 and the complementary fraction $1 - x(t)$ in country 2. The choice of producing in either country is influenced by the prevailing labor costs and labor productivity and, possibly, by *extra production costs* in the developing country because of the undersupply of public goods such as local infrastructures.[1] In a dynamic perspective, however, firms' manufacturing location choices determine changes in production costs, as the quantity of production is moved from one country to another.[2]

As commonly assumed, in each country $i \in \{1, 2\}$ labor wages are positively correlated to the domestic labor (workforce) productivity LP_i, measured by the amount of output that a worker produces in a single period of time. Moreover, (unitary) labor productivity is equal to one in both countries, but it can increase due to human capital accumulation effects and R&D spillovers, which depend on the distribution of production in the two countries (agglomeration drivers) [see, e.g., Mansfield (1988), D'Aspremont and Jacquemin (1988) and Bischi et al. (2003*b*)]. Specifically, we assume

$$LP_1(x) = 1 + \beta_1 x + \gamma_{12}(1 - x) \quad \text{and} \quad LP_2(x) = 1 + \beta_2(1 - x) + \gamma_{21} x. \quad \mathbf{(1)}$$

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Here, β_i is the coefficient of labor productivity accounting for *within-country* externalities (learning by doing and spillovers) in country i. Analogously, γ_{ij} is the coefficient of labor productivity accounting for (possible) *nearby-country* externalities in country i, which are related to similar effects coming to country i from country $j \neq i$ [see, e.g., Bischi and Lamantia (2002) and Bischi et al. (2003*a*,b)]. As we refer to country 1 as the technological leader, we assume in the following that $\beta_1 \geq \beta_2$.[3]

Empirical evidences suggest that technological spillovers are geographically constrained [see, e.g., Jaffe et al. (1993) and Rosenthal and Strange (2003)], with knowledge transfer that decreases with distance even within the same firm [see Adams and Jaffe (1996), Ellison and Glaeser (1997), and Alcácer and Chung (2007)]. Accordingly, we assume that cost-reducing externalities are higher in the country where they are developed, so that $\beta_i \geq \gamma_{ji}$.

From externality-adjusted labor productivities (1) and firms' location decision, the industry levels of employment in each country are given by

$$O_1(x) = \frac{x}{LP_1(x)} \quad \text{and} \quad O_2(x) = \frac{1-x}{LP_2(x)}. \tag{2}$$

Although employment in each country increases with its manufacturing activity, production offshoring to country 2 has an ambiguous effect on employment in country 1. On the one hand, a *direct effect* of offshoring production to country 2 is to reduce the overall manufacturing activity in country 1, as x reduces and, with it, the level of employment in country 1. On the other hand, an *indirect (or feedback) effect* of offshoring to country 2 derives from the consequent reduction of labor productivity in country 1, so that its level of employment must increase to compensate the loss of productivity.[4]

In each country, (real) wages are positively correlated to labor productivity and depend on the bargaining power of workers [see, e.g., van Ark (1995) and Meager and Speckesser (2011)]. Accordingly, we assume that

$$W_i(x) = \alpha_i LP_i(x) + \Phi_i(x), \text{ with } i = 1, 2, \tag{3}$$

where $\alpha_i \geq 0$ and $\Phi_i(x) \geq 0$, $\forall x \in [0, 1]$. Coefficient α_i is the *labor-productivity remuneration*, which measures the reactivity of wages to changes in the labor productivity, while $\Phi_i(x)$ is the *bargaining power remuneration*, that is, the impact of collective/individual bargaining on the wage levels, with higher (minimum) wages when manufacturing activity in the country increases. Notice that workers/unions' bargaining power depends on the level of offshoring/reshoring: as indicated in Ranjan (2013), Dumont et al. (2006), and Braun and Scheffel (2007), the bargaining power of trade unions in developed economies decreases because of the threat of manufacturing offshoring to developing countries, where labor legislations are more lenient. Realistically, the unitary labor cost (specifically, the minimum wage) in country 1 shrinks to contrast the risk of unemployment consequent to offshoring, whereas salaries in country 2 depend positively on the amount of offshored production, which leads to a higher employment rate and more workers' bargaining power [see Anon (2012), Fishman (2012), Porter and Rivkin (2012), Ellram (2013), and Ellram et al. (2013)]. In order to capture these effects in a simple way, we assume the following functional forms for minimum wages Φ_i:

$$\Phi_1(x) = c_1 + \phi_1 x \quad \text{and} \quad \Phi_2(x) = c_2 + \phi_2(1-x). \tag{4}$$

In equation (4), $\phi_i \geq 0$ measures the reactivity of minimum wages to manufacturing activity in country i, while c_i represents the minimum value of bargaining power remuneration. By standard assumption, minimum wages in a developing country are lower than in a developed country, so that $c_1 \geq c_2$.

Following Bischi et al. (2018), we further assume that producing in the developing country entails *extra production* costs, such as higher transportation costs because of lack of infrastructures, which represent so-called *endowment-drivers*, see Alcácer et al. (2015), or costs related to teaching and training unskilled workers. Extra production costs are assumed proportional to the level of manufacturing in the foreign country and are given by the term $k(1-x)$, where $k \geq 0$ measures the negative effect of the undersupply of public goods.[5] Following Bischi et al. (2018), extra production costs are assumed negligible in country 1, as there is abundance of skilled workers and infrastructures. Summing up, the unitary production costs in the two countries, including the cost-reducing externalities due to within-country and nearby-country spillovers, are

$$C_1(x) := \frac{W_1(x)}{LP_1(x)} = \alpha_1 + \frac{c_1 + \phi_1 x}{1 + \beta_1 x + \gamma_{12}(1-x)}, \tag{5}$$

and, considering extra production costs in country 2,

$$C_2(x) := \frac{W_2(x)}{LP_2(x)} + k(1-x) = \alpha_2 + \frac{c_2 + \phi_2(1-x)}{1 + \beta_2(1-x) + \gamma_{21} x} + k(1-x). \tag{6}$$

Recall that the entire production of the industry, normalized to one and assumed constant over time, is sold in a common market at fixed price P. Then, producing in country 1 and in country 2 generates a profit for a unit of production that depends on the level of offshoring and it is equal to $\Pi_1(x) = P - C_1(x)$ and $\Pi_2(x) = P - C_2(x)$, respectively.

As in Bischi et al. (2018), the share of the total manufacturing activity located in country 1, that is, $x(t) \in [0, 1]$, is assumed to evolve in discrete time and to obey an (exponential) replicator equation, originally proposed in Cabrales and Sobel (1992)[6]:

$$x(t+1) = f(x(t)) = (1-\alpha)x(t) + \alpha \frac{x(t)}{x(t) + (1-x(t))\, e^{\beta\left[\Pi_2(x(t)) - \Pi_1(x(t))\right]}}. \tag{7}$$

The dynamic model (7) describes the industry location patterns by introducing dynamic adjustments of the share of production in either country through manufacturing comparative advantage: the share of production in country 1 increases/decreases in the next time period when current profits are higher/lower

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in country 1 than in country 2. The intensity to which the (representative) firm moves its production from one country to the other, chasing the lower production cost, is measured by parameter β, referred to as the *intensity of choice*. As a matter of fact, changing location can be difficult for firms. In equation (7), this form of inertia is captured by parameter α: the lower the α, the more difficult changing location. Summarizing, we study the impact of heterogeneous labor policies on the offshoring process and we underline the existence of sub-optimal location patterns of manufacturing, considering in equation (7) the following parameters' space:

ASSUMPTION 1. *$c_1 \geq c_2 > 0$, $\phi_2, \phi_1 \geq 0$, $\beta_1 \geq \beta_2 \geq \gamma_{12} \geq 0$, $\beta_1 \geq \gamma_{21} \geq 0$, $k \geq 0$, $\alpha_1, \alpha_2 \geq 0, \beta > 0, 1 \geq \alpha > 0$. Moreover, P is sufficiently high to ensure the profitability of the industry.*

Next, we analyze the impact of heterogeneous labor policies, in country i described by parameters c_i, ϕ_i and α_i, as well as industrial policies, in country i described by parameters β_i and γ_{ij} (with the addition of k if $i = 2$), on the offshoring process and we underline the existence of sub-optimal spatial location patterns of manufacturing activity.

3. THE LOCATION PATTERNS OF MANUFACTURING ACTIVITY

Empirical data on the level of offshoring in the EU19[7] for the decade 2005–2015 are reported in Figure 1. Observing the data, two stylized facts emerge. The first one is given by the heterogeneous levels of offshoring among industrial sectors. Usually, labor legislations change at the national level and involve all production sectors; then labor policies should not be responsible for the heterogeneous level of offshoring among industrial sectors. Excluding labor policies, the international business literature explains the different levels of offshoring in terms of different agglomeration and endowment drivers. For instance, the technology industry is characterized by relevant investments in R&D, but its manufacturing activity is mainly standardized, and cost-reducing externalities such as R&D spillovers can easily be transferred from one country to another. Moreover, hi-tech products have typically small size and are easy to be delivered, so that transportation costs, an important driver of reshoring, are of little significance in the technological industry. As underlined in Bischi et al. (2018), all these aspects are consistent with high levels of offshoring observed in Figure 1 for the technological industry.

The second stylized fact is the absence of a noticeable reshoring process despite a reasonably-to-assume improvement in wage conditions in the developing economies over the decade 2005-2015. Documented also in several empirical contributions, see, e.g., Backer et al. (2016), this aspect underlines the need to unveil the effects of labor policies on the reshoring process in a context characterized by heterogeneous industrial policies. In this respect, the simple modeling framework previously presented is flexible enough to include both agglomeration

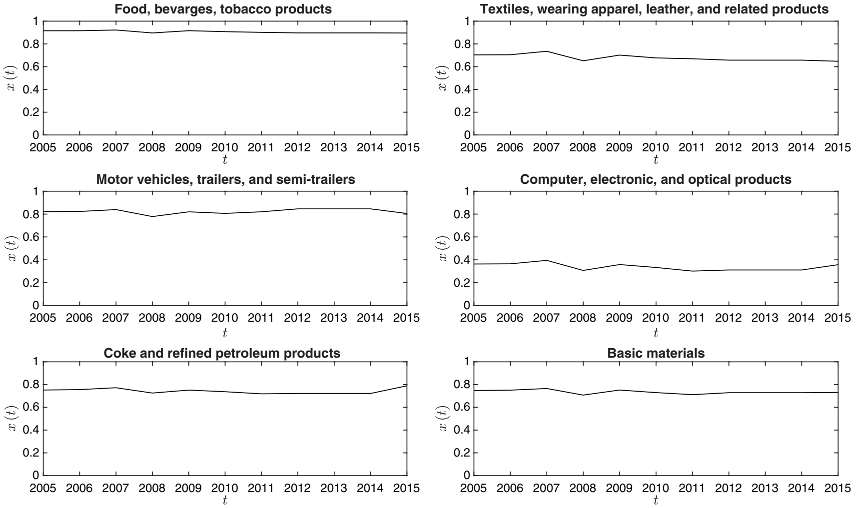

FIGURE 1. Time series of the level of reshoring in EU19 from 2005 to 2015 in six different industrial sectors. Data are provided by Eurostat, http://ec.europa.eu/eurostat/web/esa-supply-use-input-tables/data/database.

drivers and endowment drivers (industrial policies) at different extents, replicating location patterns with different levels of offshoring as shown by the dynamic analysis below, and to study the impact of labor policies. The focus is on the effects on the reshoring process of different labor policies, such as heterogeneous labor productivities, salary adjustments to labor productivity, and minimum-wage dynamics originated by an increasing bargaining power of trade unions in the technological-laggard country.

3.1. Existence and Stability of Manufacturing Location Patterns

Let us start the analysis with the main properties of the dynamical model (7) and its equilibria, which are summarized in the following theorem (all proofs are in the Appendix).

THEOREM 1. *Let us define*

$$\alpha_2^{TR_1} = \frac{\Phi_1(1)}{LP_1(1)} + \alpha_1 - \frac{\Phi_2(1)}{LP_2(1)} \quad \textit{and} \quad \alpha_2^{TR_2} = \frac{\Phi_1(0)}{LP_1(0)} + \alpha_1 - \frac{\Phi_2(0)}{LP_2(0)} - k. \tag{8}$$

Model (7) is such that:

1. $[0, 1]$ *is an invariant set, that is, if* $x_t \in [0, 1]$, *then* $x_{t+1} \in [0, 1]$, $\forall t \geq 0$.
2. *Total offshoring* $E_0 = 0$ *and total reshoring* $E_1 = 1$ *are always their equilibria.*
3. *At any time t, offshoring does not occur in* $(t, t+1]$, *that is,* $x_{t+1} \geq x_t$, *when* $C_2(x_t) \geq C_1(x_t)$ *and reshoring does not occur in* $(t, t+1]$, *that is,* $x_t \geq x_{t+1}$, *when* $C_1(x_t) \geq C_2(x_t)$.

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4. *E_1 is locally asymptotically stable for $\alpha_2 > \alpha_2^{TR_1}$ (equivalent to $C_1(1) < C_2(1)$), is unstable for $\alpha_2 < \alpha_2^{TR_1}$ (equivalent to $C_1(1) > C_2(1)$), and for $\alpha_2 = \alpha_2^{TR_1}$ (equivalent to $C_1(1) = C_2(1)$) it is stable when $C_1'(1) > C_2'(1)$, that is,*

$$\phi_2 > \phi_2^{TR_1} := (1+\gamma_{21})\left(\frac{(\beta_1-\gamma_{12})(c_1+\phi_1)}{(1+\beta_1)^2} + \frac{c_2(\beta_2-\gamma_{21})}{(1+\gamma_{21})^2} - \frac{\phi_1}{1+\beta_1} - k\right). \quad (9)$$

5. *E_0 is unstable for $\alpha_2 > \alpha_2^{TR_2}$ (also $C_1(0) < C_2(0)$, or $\phi_2 > \phi_2^{TR_2}$), is stable for $\alpha_2 < \alpha_2^{TR_2}$ (also $C_1(0) > C_2(0)$, or $\phi_2 < \phi_2^{TR_2}$), and for $\alpha_2 = \alpha_2^{TR_2}$ (also $C_1(0) = C_2(0)$) it is stable when $C_1'(0) > C_2'(0)$ (also $\phi_2 < \phi_2^{TR_2}$), where*

$$\phi_2^{TR_2} := \begin{cases} \left(\frac{\alpha_1-\alpha_2-k}{1+\beta_2} + \frac{c_1}{(1+\gamma_{12})(1+\beta_2)} - c_2\right) & \text{if } \alpha_2 \neq \alpha_2^{TR_2} \\ \frac{(1+\beta_2)^2}{1+\gamma_{21}}\left(\frac{c_1(\beta_1-\gamma_{12})}{(1+\gamma_{12})^2} + \frac{c_2(\beta_2-\gamma_{21})}{(1+\beta_2)^2} - \frac{\phi_1}{1+\gamma_{12}} - k\right) & \text{if } \alpha_2 = \alpha_2^{TR_2} \end{cases}. \quad (10)$$

6. *The equilibria of the model in $(0,1)$, the so-called interior equilibria, can be at most three, say $E_I < E_{II} < E_{III}$, where E_{III} implies E_{II}, which implies E_I. At least an interior attractor exists when neither E_0 [total offshoring] nor E_1 [total reshoring] is stable.*

Offshoring or reshoring the entire production are always equilibria of the model. Concerning their stability, the previous theorem indicates that as the cost-competitive advantage of the technological-laggard country decreases, as a consequence of increasing labor-productivity remuneration and union's bargaining power mirroring in higher minimum wages, offshoring changes from a stable long-run location pattern to an unstable one, whereas total reshoring gains stability. As indicated in the next theorem, the form through which the offshoring process is overturned in a reshoring process depends on the configurations of the manufacturing costs in the two countries, that is, on the agglomeration drivers (within-country spillovers and nearby-country spillovers) and the endowment drivers (extra production cost due to undersupply of local public goods). Therefore, the ways in which a reshoring process takes place as well as the required time may differ from industry to industry. Stable long-run location patterns where manufacturing activity is only partially located in the technological-leader country are also possible, as Theorem 1 does not exclude their existence. These equilibria correspond to cost indifference points, intersections of cost functions C_1 and C_2 (Figure 2). The following theorem indicates under which conditions heterogeneous location choices occur and to what extent they prevent a total reshoring of the manufacturing activity.[8]

THEOREM 2. ***(Offshoring/reshoring dynamics)*** *Let us consider $\alpha_2^{TR_1}$ and $\alpha_2^{TR_2}$ as defined in Theorem 1 and the values of the parameters as in Assumption 1. As the labor-productivity remuneration in the technological-laggard country increases, the transition from offshoring to reshoring takes place in the following ways:*

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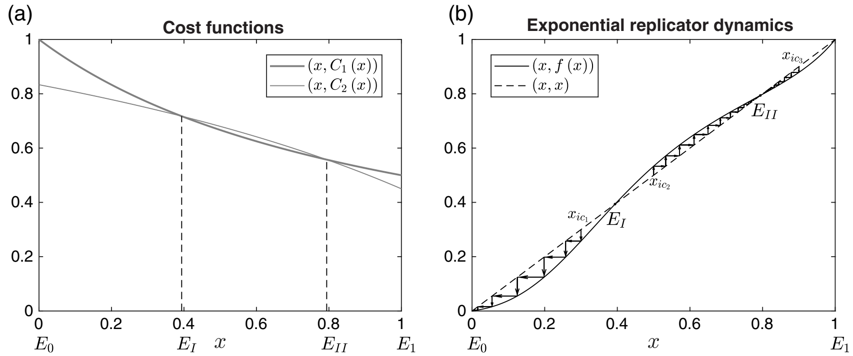

FIGURE 2. Left panel: graphs of functions $C_1(x)$, thick line, and $C_2(x)$, thin line. The intersection points of the two cost functions, say E_I and E_{II}, correspond to the interior equilibria, while E_0 denotes the offshoring equilibrium and E_1 denotes the reshoring equilibrium. Right panel: graphs of function $f(x)$, solid line, and bisector, dashed line, with three trajectories represented by staircase diagrams. The first trajectory starts in $x_{ic_1} = 0.3$ (initial condition) and converges to the offshoring equilibrium E_0, second trajectory starts in $x_{ic_2} = 0.5$ and converges to the interior equilibrium E_I as well as the third trajectory which starts in $x_{ic_2} = 0.9$. Parameters: $c_1 = 1$; $c_2 = 0.45$; $k = 0$; $\beta_1 = 1$; $\beta_2 = 0.5$; $\gamma_{12} = \gamma_{21} = 0$; $\phi_1 = 0$; $\phi_2 = 0.8$; $\alpha_1 = \alpha_2$; $\alpha = 1$; $\beta = 10$.

1. *If $\frac{\Phi_1(0)}{LP_1(0)} < \frac{\Phi_1(1)}{LP_1(1)}$ and $\frac{\Phi_2(1)}{LP_2(1)} < \frac{\Phi_2(0)}{LP_2(0)} + k\frac{1+\gamma_{21}}{1+\beta_2}$, then $\alpha_2^{TR_2} < \alpha_2^{TR_1}$ and offshoring equilibrium E_0 is a globally stable equilibrium for $\alpha_2 < \alpha_2^{TR_2}$, a unique interior equilibrium exists for $\alpha_2^{TR_2} < \alpha_2 < \alpha_2^{TR_1}$ (manufacturing activity is spread in the two countries) and it is globally stable when the intensity of choice β is small enough; finally reshoring equilibrium E_1 is a globally stable equilibrium when $\alpha_2^{TR_1} < \alpha_2$.*
2. *If $\frac{\Phi_1(0)}{LP_1(0)} > \frac{\Phi_1(1)}{LP_1(1)}$ and $\frac{\Phi_2(1)}{LP_2(1)} > \frac{\Phi_2(0)}{LP_2(0)} + k\frac{1+\beta_2}{1+\gamma_{21}}$, then $\alpha_2^{TR_1} < \alpha_2^{TR_2}$ and offshoring equilibrium E_0 is a globally stable equilibrium for $\alpha_2 < \alpha_2^{TR_1}$, an unstable and unique interior equilibrium exists and reshoring/offshoring is the only long-run location pattern for $\alpha_2^{TR_1} < \alpha_2 < \alpha_2^{TR_2}$; finally reshoring equilibrium E_1 is a globally stable equilibrium when $\alpha_2^{TR_2} < \alpha_2$.*
3. *Otherwise, up to three interior equilibria for map (7) may exist. For $\alpha_2 < \min\left\{\alpha_2^{TR_1}, \alpha_2^{TR_2}\right\}$ offshoring [reshoring] is [not] a long-run location pattern, whereas for $\alpha_2 > \max\left\{\alpha_2^{TR_1}, \alpha_2^{TR_2}\right\}$ reshoring [offshoring] is [not] a long-run location pattern.*

A cost of production in the technological-leader country that is increasing with respect to the level of reshoring implies that the cost-reducing externalities due to within-country spillovers are offset by the higher minimum wages. At the same time, a cost of production in the technological-laggard country that is decreasing with respect to the level of reshoring implies that the cost-reducing externalities due to lower minimum wages, nearby-country spillovers, and lower extra production costs offset the cost-increasing externalities due to the loss of within-country spillovers. This configuration corresponds to the first case in Theorem 2, which

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indicates that there exists a threshold value $\alpha_2^{TR_2}$ for α_2, the labor-productivity remuneration in the technological-laggard country, below which the manufacturing activity is offshored to country 2. Increasing α_2 over this threshold entails that production is shared between the two countries. Further increments of the labor-productivity remuneration above a second threshold level $\alpha_2^{TR_1}$ imply location of manufacturing activity back to the technological-leader country only, that is, complete reshoring takes place. This transition from offshoring to reshoring due to higher salaries in the technological-laggard country is smooth and gradual, as depicted in the bifurcation diagram of Figure 3(a), which shows the long-run stable manufacturing locations and their basins of attraction as a function of the labor-productivity remuneration in country 2. In this case, we observe a smooth transition from offshoring to reshoring with a unique long-run geographic distribution of manufacturing activities.

Comparative analysis shows that an increase of extra production costs (in the technological laggard country due to the undersupply of public goods) reduces the first threshold value making offshoring more sensitive to changes in α_2. On the contrary, higher within-country spillovers in the home country, with consequent higher cost-reducing externalities, lead to an increment of the ranges of labor-productivity remunerations (in the technological-laggard country) for which reshoring is a stable long-run location pattern.

The second case in Theorem 2 is the opposite one. Here, the cost of production in the technological-leader country is decreasing in the level of reshoring while the cost of production in the technological-laggard country is increasing in the level of reshoring. This configuration of cost functions indicates that in each country the agglomeration drivers, and in particular the cost-reducing externalities due to within-country spillovers, are a dominant factor which offsets the other kinds of costs. In this scenario, as the labor-productivity remuneration in country 2 is increased, the transition from offshoring to reshoring is abrupt (not gradual). In fact, offshoring is a stable long-run location pattern for low values of α_2, but as α_2 is increased, reshoring also becomes a stable lung-run location pattern. See Figure 3(b), where the green region, basin of attraction of the reshoring equilibrium, and the yellow region, basin of attraction of the offshoring equilibrium, coexist for certain values of α_2. Then, offshoring can occur until the labor-productivity remuneration in country 2 is sufficiently high. Afterwards, reshoring remains the unique stable long-run location pattern.

In the cases of asymmetric configurations of manufacturing costs, where in one country agglomeration drivers outweigh endowment drivers plus minimum wages and in the other country cost-reducing externalities due to agglomeration drivers are offset by other costs, several configurations of possible long-run locations coexist. Multiple interior equilibria can exist and be stable even for relatively low or relatively high values of the labor-productivity remuneration [see, e.g., Figure 3(c)]. In these cases, the possibility to forecast the behavior of the model by analytical results is more difficult and a global analysis of the

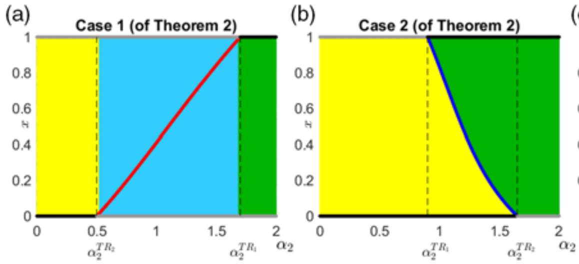

FIGURE 3. Bifurcation diagrams with bifurcation parameter α_2 varying in $[0, 2]$. The equilibria of offshoring and reshoring, say E_0 and E_1, are in black if stable and in gray if unstable. Inner equilibria are represented in the blue (unstable) and red (stable) curves as α_2 increases. For each value of α_2 in $[0, 2]$, the basin of attraction of the reshoring equilibrium E_1 is represented in green, in yellow that of the offshoring equilibrium E_0, and in azure the basin of the interior equilibrium (red curve). The bifurcation value for the offshoring equilibrium $\alpha_2^{TR_2}$ (transcritical bifurcation) is indicated by a black dashed line as well as the bifurcation value for the reshoring equilibrium $\alpha_2^{TR_1}$ (transcritical bifurcation). Parameters: $c_1 = 1$; $c_2 = 0.5$; $\beta_1 = 1.5$; $\beta_2 = 1$; $\gamma_{12} = \gamma_{21} = 0$; $\alpha_1 = 1$; $\alpha = 1$; and $\beta = 1$. Moreover, $\phi_1 = 2$, $\phi_2 = 1$, and $k = 0.75$ in panel (a), $\phi_1 = 0$, $\phi_2 = 0$, and $k = 0.1$ in panel (b), and $\phi_1 = 0$, $\phi_2 = 1$, and $k = 0.6$ in panel (c).

manufacturing location dynamics is required. Therefore, also the policy measures to be undertaken have to be tuned with attention.

So far, the main insight is that increasing the labor-productivity remuneration in the technological-laggard country reduces the risk of offshoring, but there are many ways in which this may occur and it depends on the manufacturing cost configuration in each country, that is, on agglomeration drivers, endowment drivers, and minimum wages. Since policy makers are not usually informed about firms' production costs, the effects of labor policies aimed to increase/reduce the labor-productivity remuneration may have unpredictable consequences. However, the analytical results in Theorems 1 and 2 provide useful information about the possible achievements of policy measures that increase/reduce agglomeration drivers, endowment drivers, and wages in order to increase the level of manufacturing activity in a country.

In sum, the agglomeration drivers positively impact on manufacturing costs and influence the location decisions of MNEs. By increasing the R&D activities in a technological-leader country, policy makers increase the cost-reducing externality due to within-country spillovers and increase the chance to attract MNEs. Nevertheless, this policy may be insufficient to revert offshoring from stable to an unstable equilibrium, and its effectiveness vanishes in case of uniform diffusion of asymmetric spillovers. In the geographic distribution of the manufacturing activities, a key role is played by the endowment drivers, such as infrastructures and facilities. Theorems 1 and 2 indicate that asymmetric endowment drivers reduce the attractiveness of the offshoring strategy, but they may not ensure reshoring, as extra production costs do not impact on the stability of reshoring equilibrium. A similar role is played by the minimum-wage policy, which increases the attractiveness of the domestic economy but can even reduce the attractiveness of production abroad.

3.2. Efficiency of the Asymptotically Stable Manufacturing Location Patterns

The analysis so far focused on stable long-run location patterns. Stability is only one feature of a manufacturing location. The second important aspect is its efficiency, a concept that in the current modeling setup coincides with profitability as market demand effects are neglected.

DEFINITION 1. ***(Efficiency/suboptimality for a geographic organization of the manufacturing activity)*** *A geographic distribution of the manufacturing activity is more efficient than another one when it allows the industry to manufacture the output that satisfies the market demand at a lower total cost of production. A geographic configuration of the manufacturing activity is suboptimal when a more efficient one exists.*

By comparing offshoring with reshoring outcomes, the following Lemma indicates under which condition the offshore choice is more efficient (more profitable) than reshoring.

LEMMA 1. *Let us define*

$$\phi_2^{off/re} = \left(\alpha_1 - \alpha_2 - k + \frac{c_1 + \phi_1}{1 + \beta_1}\right)(1 + \beta_2) - c_2. \qquad \textbf{(11)}$$

Then,

1. *For $\phi_2 < \phi_2^{off/re}$, total offshoring is more profitable for firms than total reshoring.*
2. *For $\phi_2 > \phi_2^{off/re}$, total reshoring is more profitable for firms than total offshoring.*

The threshold value determining the efficiency of offshoring [reshoring] with respect to reshoring [offshoring] does not correspond to the threshold levels for the stability of manufacturing location patterns of offshoring [reshoring]. At a policy level, this implies a trade-off so that the policy maker has to pay attention to the stability of the preferred location pattern more than to the efficiency of the location of manufacturing. The trade-off between asymptotic stability and an efficient location choice involves even the interior equilibria. In fact, applying the results of Theorem 1 we can prove the following Corollary, which shows, in a simple setting, the non-correspondence between a stable interior equilibrium of the adjustment process (7) and an efficient production plan, which, in fact, minimizes overall production costs.

COROLLARY 1. *Let us assume $\gamma_{21} = \beta_1$, $\gamma_{12} = \beta_2$, $k = 0$, $\alpha_1 = \alpha_2$ and $\phi_2 > c_1 - c_2 > -\phi_1$. Then total offshoring and total reshoring are unstable equilibria,*

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a locally stable interior equilibrium $E_I \in (0, 1)$ always exists for (7), provided that the intensity of choice is sufficiently low, but the industry would produce at a lower cost locating all production in one country.

The last result underlines that asymptotic stability does not necessarily correspond to efficiency, which indicates that MNEs can select an inefficient manufacturing location in the long run. The consequences in terms of cost of manufacturing, wages, and employment are discussed in the following section, together with an investigation of the economic policy implications of such suboptimal learning process.

4. OFFSHORING VERSUS RESHORING: EFFICIENCY, STABILITY, AND ECONOMIC IMPLICATIONS

The presence of stable suboptimal location patterns has relevant implications in terms of effectiveness of labor and industrial policy measures and indicates that a geographic region that offers a manufacturing cost advantage is not necessarily selected by MNEs. The scope of this section is to scrutinize the learning mechanism behind this suboptimal geographical selection and the possible repercussions in terms of wages, employment, and offshoring/reshoring of the manufacturing activity. The focus is on the dynamics of the minimum wage in the technological-laggard country and therefore on parameter ϕ_2. To better understand the phenomenon, let us start considering a limiting case that shows the suboptimal location patterns even in the case of identical labor-productivity remunerations and assuming only within-country spillovers. Moreover, let us set the agglomeration drivers for the technological-advanced country so that $C_1(1) = C_2(1)$. The latter equation indicates that for a MNE, it is indifferent between producing in either country when all manufacturing are located in country 1.

Under this particular setting, we consider six different scenarios, ranging from the case of no within-country spillovers advantage for the technological-leader country and zero extra production costs for the technological-laggard country, to the case of huge within-country spillover advantage for the technological-leader country and extra production costs equal to half the labor cost in the technological-laggard country adjusted for the domestic labor productivity. For each scenario, we investigate the manufacturing location choice of MNEs when ϕ_2 increases, that is, varying the coefficient that measures the increments in the minimum wage of the technological-laggard country as a consequence of offshoring. The constellation of the parameters is chosen in such a way that offshoring is profitable for the industry and it offers both a comparative cost advantage for every firm and an absolute cost advantage for the industry itself as long as $\phi_2 \in \left(0, \phi_2^{off/re}\right)$. Under this condition, the loss of labor productivity and the extra production costs due to offshoring are offset by lower salaries in country 2, where MNEs locate their entire production, which represents, therefore, an optimal solution compared to reshoring. For $\phi_2 \in \left(\phi_2^{off/re}, \phi_2^{TR_2}\right)$ reshoring

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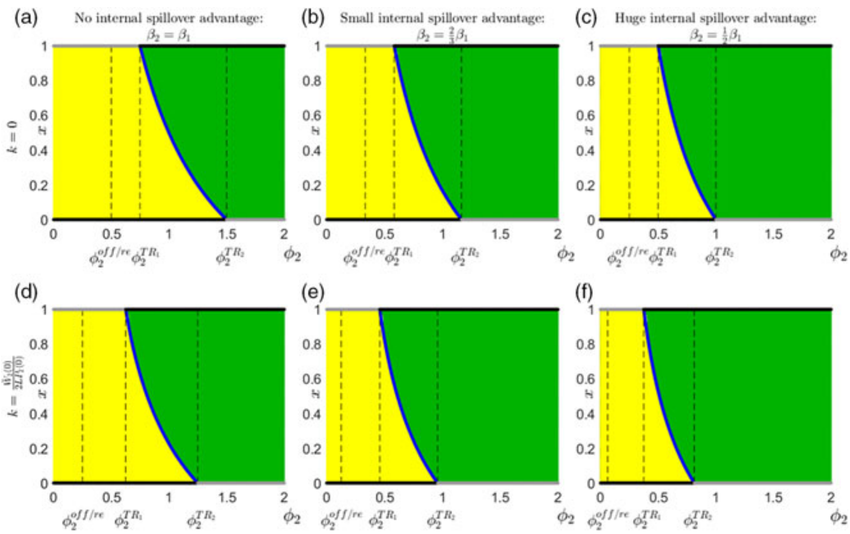

FIGURE 4. Bifurcation diagrams for the model with bifurcation parameter ϕ_2 varying in $[0, 2]$. The equilibria of offshoring and reshoring, say E_0 and E_1, are in black if stable and in gray if unstable. The blue curves indicate the interior equilibria (unstable), as ϕ_2 increases. For each value of ϕ_2 in $[0, 2]$, the basin of attraction of the reshoring equilibrium E_1 is in green, the yellow region that of the offshoring equilibrium E_0. The bifurcation value for the offshoring equilibrium $\phi_2^{TR_2}$ (transcritical bifurcation) is indicated by a black-dashed line as well as the bifurcation value for the reshoring equilibrium $\phi_2^{TR_1}$ (transcritical bifurcation) as well as the threshold value for offshoring equilibrium being an optimal solution compared to reshoring, that is, $\phi_2^{off/re}$. Parameters: $c_1 = 1$; $c_2 = 0.5$; $\beta_1 = 1$; $\gamma_{12} = \gamma_{21} = 0$; $\phi_1 = 0$; $\alpha_1 = \alpha_2$; $\alpha = 1$; $\beta = 1$. Moreover, $k = 0$ in the first row (no extra production costs), $k = \frac{1}{2}\frac{W_2(0)}{LP_2(0)}$ in the second row (extra production cost is half of the unitary labor cost adjusted for domestic labor productivity in case of offshoring), first column $\beta_2 = \beta_1$ (symmetric within-country spillovers), second column $\beta_2 = \frac{2}{3}\beta_1$ (within-country spillovers advantage for the technological-leader country), and third column $\beta_2 = \frac{1}{2}\beta_1$ (huge within-country spillovers advantage for the technological-leader country).

becomes more profitable than offshoring. Nevertheless, the technological-laggard country maintains a comparative cost advantage as indicated by its global stability, see Figure 4 where the basin of attraction of offshoring is indicated in yellow as a function of ϕ_2. For example, assuming parameters as in Figure 4, first line, $\phi_2 = 0.5 \in \left(\phi_2^{off/re}, \phi_2^{TR_2}\right)$ and MNEs that opt for offshoring, the minimum wage in the technological-laggard country equals the one in the technological-leader country, say $c_2 + \phi_2 = c_1$. However, manufacturing in the technological-laggard country still offers a comparative cost advantage due to within-country spillovers. In fact, when the manufacturing activity is concentrated in the technological-laggard country, cost-reducing externalities originated from R&D spillovers are produced in this region only and cannot be transferred in the technological-leader country. On the other hand, comparing reshoring with offshoring, the technological-leader country offers a labor-cost advantage and an extra production-cost advantage, which makes this location choice more efficient than offshoring. Despite that, MNEs offshore totally their production, as indicated by the bifurcation diagrams in Figure 4, first line, where the yellow region represents the basin of attraction of offshoring equilibrium E_0, which is $\mathcal{B}(E_0) = [0, 1)$ for $\phi_2 = 0.5$. As the extra production costs increase, the range of values for which offshoring is both a stable and suboptimal location pattern enlarges, compare first and second lines in Figure 4. This numerical example indicates that offshoring may persist even though it is suboptimal thus providing a game-theoretical explanation for the mild reshoring process started in the last decade due to increased salaries in technological-laggard countries [see, e.g., Backer et al. (2016)].

4.1. Offshoring as an Inefficiency Trap: Labor and Industrial Policy Implications

The phenomenon of offshoring leading to suboptimal outcomes is clearly observable in Figure 5, where the costs of production in the two countries are depicted as a function of the level of reshoring. As observable, producing in the technological-leader country offers the highest cost advantage due to its higher labor productivity and represents the most efficient solution. However, offshoring is the strategy that offers the highest relative advantage: it reduces the overall efficiency of the industry, with higher costs in the technological-leader country than in the technological-laggard one independently on the level of offshoring. Hence, MNEs have an incentive to offshore, although this myopic behavior leads to lower profitability of the industry because of the higher production costs, as depicted in Figure 5. The economic explanation behind this dynamic phenomenon can be synthesized as follows. Although for any given level of offshoring, unitary production in the technological-leader country is more expensive than in the technological-laggard country, moving the manufacturing to the technological-laggard country may increase the average cost of production instead of reducing it because of the loss of labor productivity in country 1, which is more than offset by the cost-reducing externalities offered by offshoring. Thus, manufacturing activity can be geographically concentrated in suboptimal locations, giving rise to inefficiency traps. The economic message that comes out of this example is: *moving the production in the location that has the higher costs of production today can reduce the cost of production of tomorrow*. The outcome is similar to the *prisoner-dilemma scenario* described by Schelling in Schelling (1973), which can be denominated by the *offshoring-reshoring dilemma* in the geographic distribution of the manufacturing activity. In evolutionary game theory, this phenomenon often arises and is known as *spiteful behavior* [see, e.g., Hamilton (1970)]. Assuming that the industry is populated by a given number of MNEs, a single MNE offshores its production to the technological-laggard country, because this

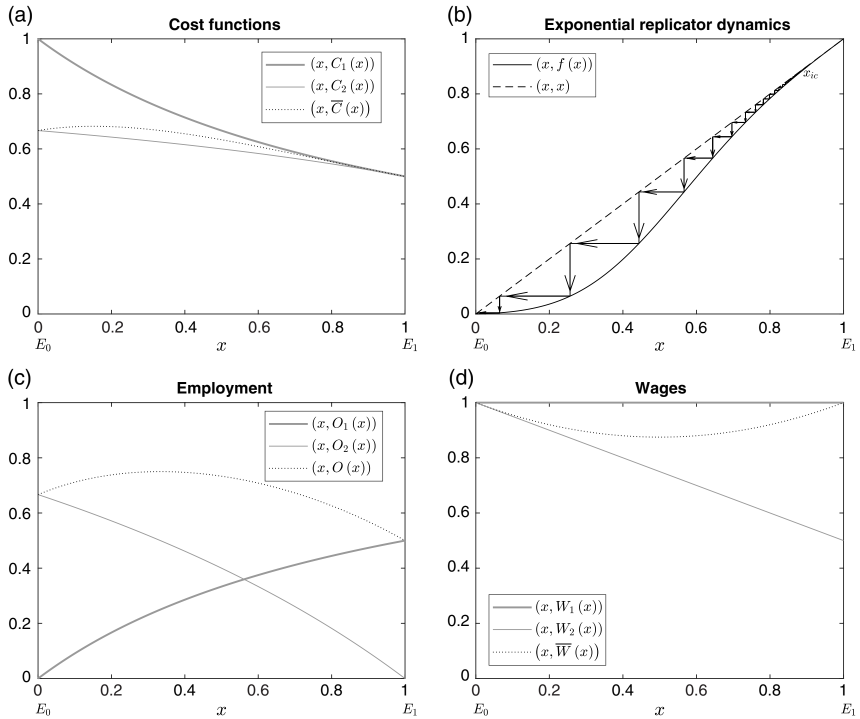

FIGURE 5. Top-left panel: graph of function $C_1(x)$, thick line, graph of function $C_2(x)$, thin line, graph of the average cost function $\overline{C}(x) = xC_1(x) + (1 - x)C_2(x)$, dotted line. Top-right panel: graph of function $f(x)$, solid line, bisector, dashed line, and the staircase diagram shows the trajectory that starts in $x_{ic} = 0.9$ (initial condition) and converges to the offshoring equilibrium E_0 while the reshoring equilibrium E_1 is unstable. Bottom-left panel: level of employment for the industry in the technological-leader country $O_1(x)$, thick line, in the technological-laggard country $O_2(x)$, thin line, and level of employment for the industry $O(x) = O_1(x) + O_2(x)$, dotted line. Bottom-right: unitary wage in the technological-leader country $W_1(x)$, solid line (identically equal to one), in the technological-laggard country $W_2(x)$, dashed line, and the average unitary wage in the industry $\overline{W}(x) = xW_1(x) + (1 - x)W_2(x)$, dotted line. Parameters: $c_1 = 1$; $c_2 = 0.5$; $\beta_1 = 1$; $\beta_2 = \frac{1}{2}\beta_1$; $\gamma_{12} = \gamma_{21} = 0$; $k = 0$; $\phi_1 = 0$; $\phi_2 = \frac{1}{2}$; $\alpha_1 = \alpha_2$; $\alpha = 1$; $\beta = 10$.

choice provides a cost advantage for itself. In the end, all MNEs engage in offshoring, which becomes the long-run location pattern, despite its suboptimality with respect to reshoring.

In terms of policy implications, this last example suggests that reshoring is hampered by a minimum salary policy that is not linked to the current level of manufacturing activity in the domestic country. Indeed, a globally stable suboptimal offshoring equilibrium implies the following condition $C_1(0) > C_2(0) >$

$C_1(1) > C_2(1)$, which, in case of within-country spillovers only and symmetric labor-productivity remunerations, is equivalent to the following condition:

$$c_1 > \frac{c_2 + \phi_2}{1 + \beta_2} + k > \frac{c_1 + \phi_1}{1 + \beta_1} > c_2. \quad \textbf{(12)}$$

Therefore, as long as $c_2 > 0$, if c_1 is sufficiently low and ϕ_1 sufficiently high, it is $C_1(0) < C_2(0) > C_1(1) > C_2(1)$. This latter condition implies that neither reshoring nor offshoring is a stable configuration, and at least a stable long-run geographic location exists such that manufacturing is shared in both countries, see Theorem 1. Therefore, if ϕ_1 is high enough, the minimum wage in the domestic country is not negatively affected by a low value of c_1, and it is possible to reduce the incentive to offshore without impacting wage level.

The example discussed so far proves the following theorem, which contains a significant indication of labor and industrial policy design.

THEOREM 3. *Labor and industrial policy measures aimed at making the technological-leader country a more efficient location choice than the technological-laggard country are not sufficient to prevent offshoring.*

The previous statement indicates that evolutionary-learning schemes impact on the effectiveness of policy measures and may lead to undesired results and macro-patterns that are not consistent with the profit-maximization principle of a single MNE.

Condition (12) for the existence of a suboptimal offshoring in the form of a prisoner dilemma provides further policy implications. It indicates that even with equal minimum salary policies in the two countries, that is, $c_1 = c_2$, the risk of offshoring still persists, as to prevent it also condition $c_2 < \frac{\phi_2 + k}{\beta_2} + k$ is required. Thus, the success of minimum salary policies in the domestic country for a reshoring process depends on the labor market conditions and on the extra production cost in the foreign country. On the other hand, implementing a policy measure to increase the strength of agglomeration drivers in the domestic country, such as increasing β_1, could at most avoid that $C_1(1) > C_2(1)$, that is, avoid that reshoring be an unstable geographic location of the manufacturing activity, despite its being more efficient than offshoring. However, that measure alone does not prevent the risk of offshoring, because it does not allow to having $C_1(0) < C_2(0)$.

A numerical investigation, not reported here for the sake of space, indicates that an increase of the labor productivity in the technological-leader country reduces the global stability of offshoring equilibrium, but it does not make it unstable either, as already inferred from condition (12). In this respect, R&D activity does not represent a barrier to offshoring or, equivalently, an economy with high levels of labor productivity is not immune to offshoring, even when offshoring is an inefficient location choice. Despite the risk of offshoring, a positive effect of within-country spillovers in the domestic country is to increase the average salaries of the industry employees.

An increase of the unions' bargaining power, which mirrors in higher salaries, may, however, reduce the cost advantage offered by the technological-laggard country and the risk of offshoring disappears (see the bifurcation diagrams in Figure 4). It is also worth underlining that $\phi_2 > \phi_2^{TR_2}$ implies $C_2(0) > C_1(0)\ (> C_1(1))$ (see Theorem 1). Let us further point out that, despite what observed in the bifurcation diagrams in Figure 4 which represent the particular case $C_2(1) = C_1(1)$, in general, an increase of ϕ_2 does not convert reshoring into a stable equilibrium. Thus, contrary to what the *common wisdom* may suggest, when minimum salaries increase in a technological-laggard country due to increased local manufacturing activity that sparks unions' bargaining power, the reshoring of the entire production in the technological-leader country may not occur. This is consistent with the empirical observations indicating a mild reshoring, although there is an increase of labor costs in developing economies.

So far, we have focused on zero nearby-country spillovers, meaning that the cost-reducing externalities are geographically constrained to the country/region where they are originated. However, some industrial sectors are characterized by an almost free geographic transferability of knowledge and spillovers. Considering the benchmark case of free geographic transferability of within-country spillovers, the condition for a stable and suboptimal offshoring equilibrium becomes:

$$(c_1 >)\ \frac{c_1}{1+\beta_2} > \frac{c_2+\phi_2}{1+\beta_2} + k > \frac{c_1+\phi_1}{1+\beta_1} > (c_2 >)\ \frac{c_2}{1+\beta_1}, \qquad \mathbf{(13)}$$

which indicates that uniformly distributed spillovers leave unaltered the relation $C_2(0) > C_1(1)$ and may only revert the condition $C_1(0) > C_2(0)$, that is, they can reduce the risk of offshoring, but the possibility of reshoring remains zero. The situation is only worsened in the case of asymmetric transferability of spillovers between the two countries. For example, let us consider the case of free-diffusion of R&D spillovers from the domestic to the foreign country. Then the possibilities of reshoring, which is more efficient than offshoring, are only reduced, as underlined by the bifurcation diagrams in Figure 6. In this case, the *offshoring–reshoring dilemma* persists even for high levels of the unions' bargaining power in the technological-laggard country that mirrors in higher values of ϕ_2. In fact, despite the presence of extra production costs and being a suboptimal strategy, the high levels of wages in the technological-laggard country do not prevent offshoring. This is in line with the mild level of reshoring of the last decades, despite the increasing minimum wages in the technological-laggard countries. The example depicted in Figure 6 indicates that the phenomenon of offshoring/reshoring dilemma is emphasized in industrial sectors with asymmetric within-country spillovers, specifically when the R&D spillovers can be transferred from the technological-leader country to the technological-laggard country but not the vice-versa. This is consistent with the empirical observations of low levels of reshoring in the hi-tech industries, characterized by high geographic transferability of knowledge.

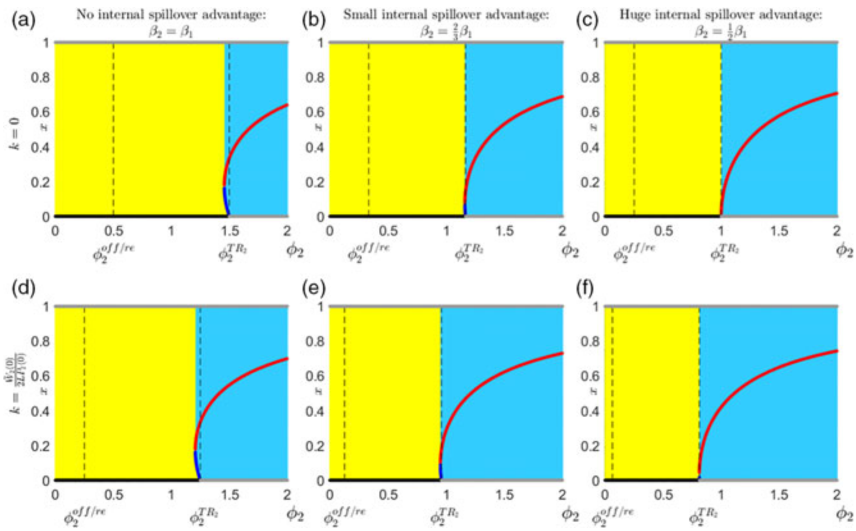

FIGURE 6. As in Figure 4, with the addition that the red curve indicates the locally asymptotically stable interior equilibria as the bifurcation parameter ϕ_2 increases and for each ϕ_2 in $[0, 2]$ the azure segment is the basin of attraction of the interior equilibrium (red curve). Parameters: $c_1 = 1$; $c_2 = 0.5$; $\beta_1 = 1$; $\gamma_{12} = 0$; $\gamma_{21} = \beta_1$; $\phi_1 = 0$; $\alpha_1 = \alpha_2$; $\alpha = 1$; $\beta = 1$. Moreover, $k = 0$ in the first line (no extra production costs), $k = \frac{1}{2}\frac{W_2(0)}{LP_2(0)}$ in the second line (extra production cost is half of the unitary labor cost adjusted for domestic labor productivity in case of total offshoring), first column $\beta_2 = \beta_1$ (symmetric within-country spillovers), second column $\beta_2 = \frac{2}{3}\beta_1$ (within-country spillovers advantage for the technological-leader country), and third column $\beta_2 = \frac{1}{2}\beta_1$ (huge within-country spillovers advantage for the technological-leader country).

In case of asymmetric labor-productivity remunerations ($\alpha_1 \neq \alpha_2$), the condition for a suboptimal and stable offshoring equilibrium becomes

$$\alpha_1 + \frac{c_1}{1+\beta_2} > \alpha_2 + \frac{c_2+\phi_2}{1+\beta_2} + k > \alpha_1 + \frac{c_1+\phi_1}{1+\beta_1} > \alpha_2 + \frac{c_2}{1+\beta_1}. \qquad \mathbf{(14)}$$

Therefore, if α_2 is sufficiently high (α_1 cannot be negative), it is possible to reduce α_1 in order to have $C_2(0) > C_1(0) > C_2(1) > C_1(1)$. According to Theorem 1, this configuration of production costs implies that: (a) offshoring is not a stable configuration, since $C_2(0) > C_1(0)$; (b) reshoring is a stable configuration, since $C_2(1) > C_1(1)$; and (c) reshoring remains (obviously) the most efficient location choice for firms, since $C_2(0) > C_1(1)$. Then, a policy measure aimed at modifying the labor-productivity remunerations may be effective even for overcoming suboptimal geographic concentration of the manufacturing activity, but it is not always feasible as it depends on the labor policies adopted in the technological-laggard country. Even when it is feasible, this policy measure, if adopted, reduces real wages. For example, reducing the labor-productivity remunerations may not be sufficient to ensure condition $C_2(0) > C_1(0) > C_2(1) > C_1(1)$, as well as

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$W_1(1) > W_2(0)$, that is, high level of wages and investments to increase the labor productivity in the technological-leader country may be required.

4.2. Reshoring as an Inefficiency Trap: Labor and Industrial Policy Implications

The mirror issue is expressed by the question whether the offshoring-reshoring dilemma may occur in a configuration where total reshoring is a stable equilibrium despite manufacturing in the domestic country is a suboptimal choice. This scenario represents a sort of "optimal" labor policy for the technological-leader country, in the sense that it allows to attract the entire manufacturing activity and to have salaries that are higher than in the technological-laggard country. In fact, this configuration requires

$$C_1(0) < C_2(0) < C_1(1) < C_2(1). \tag{15}$$

The condition $C_1(1) > C_2(0)$ implies that reshoring is a suboptimal solution with respect to offshoring; the condition $C_2(1) > C_1(1)$ entails that reshoring is a stable industry configuration; finally, $C_2(0) > C_1(0)$ implies that offshoring is an unstable equilibrium of the industry (see Theorem 1). Let us further note that $C_1(1) > C_2(0)$ implies $W_1(1) > W_2(0)$, indeed

$$\alpha_1 + \frac{c_1+\phi_1}{1+\beta_1} > \alpha_2 + \frac{c_2+\phi_2}{1+\beta_2} + k \Rightarrow \alpha_1(1+\beta_1) + c_1 + \phi_1 > \alpha_2(1+\beta_2) + c_2 + \phi_2. \tag{16}$$

This situation is an ideal one for the policy maker of the technological-leader country, as also indicated in the numerical example of Figure 7, which underlines that reshoring is a stable equilibrium and the level of employment, as well as the salaries ensured by reshoring, is as high as the ones implied by offshoring, which remains an unstable configuration.

The examples discussed in this section prove the following theorem, which contains a second indication of labor and industrial policy design.

THEOREM 4. *Labor and industrial policy measures aimed at making the technological-leader country a more efficient location choice than the technological-laggard country are neither necessary nor sufficient to prevent offshoring.*

5. CONCLUSIONS

The simple game-theoretical framework proposed in this paper describes MNEs that move their production either in a technological-laggard country to exploit low labor costs (offshoring) or in a technological-leader country to take advantage of the cost-reducing externalities coming from within-country spillovers (reshoring). The manufacturing costs are characterized by asymmetric labor-productivity remunerations, asymmetric collective or individual bargaining

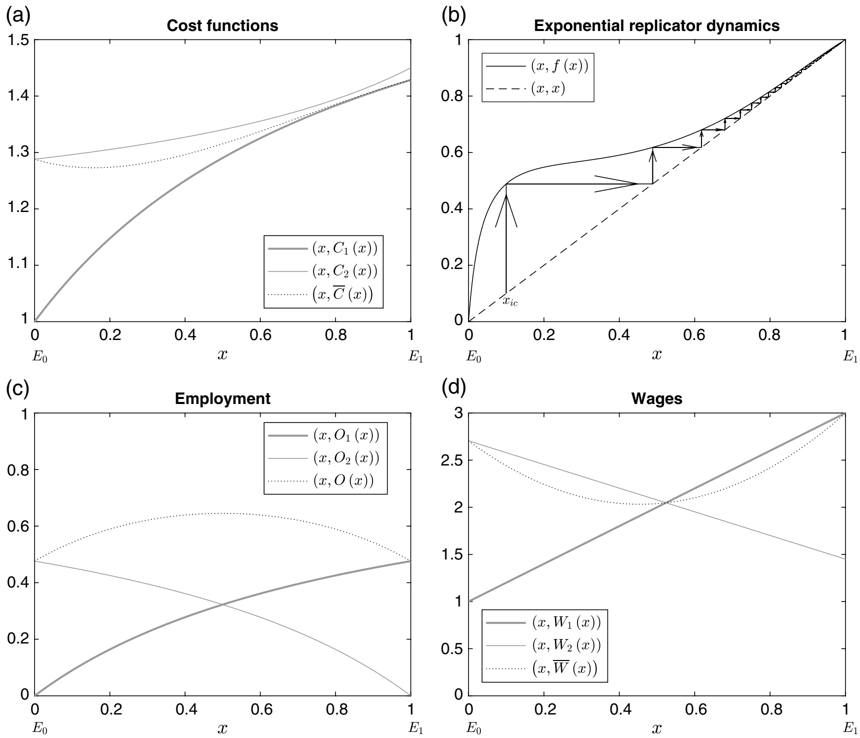

FIGURE 7. Meaning of the pictures as in Figure 5. In the top-right panel, the staircase diagram shows the trajectory that starts in $x_{ic} = 0.1$ (initial condition) and converges to the reshoring equilibrium E_1 while the offshoring equilibrium E_0 is unstable. Parameters: $c_1 = 1$; $c_2 = 0.9$; $\beta_1 = \beta_2 = 1.1$; $\gamma_{12} = \gamma_{21} = 0$; $k = 0$; $\phi_1 = 2$; $\phi_2 = 0.65$; $\alpha_1 = \alpha_2$; $\alpha = 1$; $\beta = 10$.

power remunerations, labor-productivity externalities coming from technological spillovers within-country and between countries (the so-called agglomeration drivers), and endowment factors such as extra production costs in the low-wage economy. The investigation reveals that an increasing labor-productivity remuneration in the technological-laggard country favors reshoring, but the extent and timing of this process depend on the cost externalities due to endowment drivers and agglomeration drivers that characterize a specific industry. A flexible labor policy in the technological-laggard country, such as workers' bargaining power remuneration indexed to the domestic manufacturing activity, can narrow the reshoring process and the dynamic of the model underlines the presence of sub-optimal location patterns, like inefficiency traps. It follows that economic policy measures designed to increase the cost competitiveness of the domestic economy are neither sufficient nor necessary to avoid offshoring.

Conflict of Interest

The authors declare that they have no conflict of interest.

NOTES

1. The impact of infrastructure endowments on the production costs of a firm is well documented in the economic geography. For example, Oates (1995) writes of a *favorable business climate* to refer to the extent and condition of transportation system, the quality of local schools, and the general structure and level of local taxes that influence business location decision. Moreover, Maurer and Walz (2002) consider a game-theoretical model to describe oligopolistic firms' geographic location decisions in which publicly provided local inputs reduce firms' costs by a given coefficient (assuming decreasing return to scale in the government local input production). Justman et al. (2002) investigate the relation between local infrastructure quality and firms' location patterns. In the NEG framework, Ihara (2008) studies the impact of the provision of local public goods on the capital mobility. Let us further point out that local public goods does not refer to public expenditures targeted to specific firms such as production subsidies, which are not usually allowed as it is the case in the European Union (see the prohibition of production subsidies in the Treaty of Rome). They refer to systematic expenditure biases, which are robust against anti-discrimination rules in a way that firm-specific ones may not be [see, e.g., Keen and Marchand (1997)].

2. Country 1 and country 2 are regarded as national economies instead of two generic regions as the economic policies that distinguish these two locations are defined at national level. For example, the minimum wage policy is established through collective bargaining agreements concluded at national level.

3. The technological spillovers belong to the so-called *agglomeration drivers* as the possibility to exploit such cost-reducing externalities (or equivalently labor-productivity increasing externalities) offered by the R&D investments in a single country depends on the level of agglomeration/concentration of activity in that specific country.

4. The direct and indirect effects of offshoring in the level of employment in the domestic country can explain one of the main stylized facts of unemployment dynamics: the non-monotonic relationship between the cost advantage of offshoring and the level of unemployment. In this respect, empirical observations underline that a small cost advantage offered by offshoring (and consequently a limited level of offshoring) increases (instead of decreasing) the level of employment in the home country, while a huge cost advantage of offshoring (strong offshorability and high levels of offshoring) gradually decreases the level of employment in the home country [see, e.g., Ranjan (2013)].

5. As specified, for example, in Porter and Rivkin (2012) and Ellram et al. (2013), the extra production cost due to under-provision of local public goods is becoming the main driver of reshoring in the last years, because an increasing bargaining power gained by unions in the developing economies has reduced the salary gap between countries.

6. The replicator equation (7) describes an evolutionary selection mechanism and, differently from the classical replicator dynamics, see, for example, Hofbauer and Sigmund (2003) and references therein, it has the property that the state space $[0, 1]$ is invariant under the dynamics of equation (7).

7. The group of the first 19 countries to join the EU, namely: Belgium, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Austria, Portugal, Slovenia, Slovakia, Finland.

8. Let us point out that hereafter an attractor is defined *globally stable* if its basin of attraction is $[0, 1] \setminus L$, where L is a subset of zero measure of $[0, 1]$.

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APPENDIX

Proof of Theorem 1. (1) Let us note that $f(x) \in [0, 1]$ $\forall x \in [0, 1]$. Hence $[0, 1]$ is an invariant set for f. (2) Since $f(0) = 0$ and $f(1) = 1$, $E_0 = 0$ and $E_1 = 1$ are always equilibria of the model. (3) A sufficient condition for $f(x) \geq x$ is that $C_2(x) \geq C_1(x)$, while a sufficient condition for $f(x) \leq x$ is that $C_2(x) \leq C_1(x)$. (4) By property 3 and the continuity of the function $C_1(x) - C_2(x)$, condition $C_1(1) - C_2(1) < 0$ implies that there exists a $\delta > 0$ such that $C_1(x) - C_2(x) < 0, \forall x \in (1 - \delta, 1)$. Thus $f(x) > x, \forall x \in (1 - \delta, 1)$, from which the stability of E_1 follows, being $[0, 1]$ an invariant set. Moreover, when

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$C_1(1) = C_2(1)$ the equilibrium E_1 is non-hyperbolic, being $f'(1) = 1$, and its stability must be ascertained by the (strict) convexity of $f(x)$ in a left neighborhood of $x = 1$. The property hence follows by noticing that $f''(1) = 2\alpha\beta\left(C_1'(1) - C_2'(1)\right)$, which can be rewritten as equation (9). (5) Similarly to the case (4), $C_2(0) - C_1(0) < 0$ implies that there exists a $\delta > 0$ such that $C_2(x) - C_1(x) < 0$, $\forall x \in (0, \delta)$. Thus $f(x) < x$, $\forall x \in (0, \delta)$, from which the stability of E_0 follows, being $[0, 1]$ an invariant set. Moreover, when $C_1(0) = C_2(0)$, the equilibrium E_0 is non-hyperbolic, and its stability follows by the strict concavity of $f(x)$ in a right neighborhood of $x = 0$. From $f''(0) = -2\alpha\beta\left(C_1'(0) - C_2'(0)\right)$ condition (10) follows. (6) Equilibrium condition $f(x^*) = x^*$ for $x^* \in (0, 1)$ is equivalent to $C_1(x^*) - C_2(x^*) = 0$, which is equivalent to $p(x) = 0$, where $p(x)$ is a third-degree polynomial. Hence, the maximum number of interior equilibria is three. Moreover, since the set $[0, 1]$ is invariant for f, if E_1 and E_0 are unstable, it follows that at least an interior attractor exists. □

Proof of Theorem 2 *(Offshoring/reshoring dynamics).* Assumption 1 implies

$$\frac{dC_1}{dx} = \frac{\phi_1\left(1+\gamma_{12}\right) - c_1\left(\beta_1 - \gamma_{12}\right)}{(1+x(\beta_1 - \gamma_{12}) + \gamma_{12})^2} > 0 \quad \text{and} \quad \frac{dC_2}{dx} = \frac{-(\gamma_{21}+1)\phi_2 + c_2(\beta_2 - \gamma_{21})}{(1+\beta_2 + x(\gamma_{21} - \beta_2))^2} - k < 0, \tag{A.1}$$

when $\frac{\Phi_1(0)}{LP_1(0)} < \frac{\Phi_1(1)}{LP_1(1)}$ and $\frac{\Phi_2(1)}{LP_2(1)} < \frac{\Phi_2(0)}{LP_2(0)} + k\frac{1+\gamma_{21}}{1+\beta_2}$, whence the difference in production costs

$$\Delta C(x) = \Pi_1(x) - \Pi_2(x) = -C_1(x) + C_2(x) \tag{A.2}$$

is downward sloping in x. Thus, at most one interior equilibrium $E_I = x^* \in (0, 1)$ exists and, since $\Delta C(x)$ is a continuous function and downward sloping, its existence implies $\Delta C(0) > 0 > \Delta C(1)$, that is, both E_1 and E_0 are unstable. In this case, $\alpha_2^{TR_2} < \alpha_2^{TR_1}$ and $\alpha \in \left(\alpha_2^{TR_2}, \alpha_2^{TR_1}\right)$. Moreover, when x^* exists we have

$$f'(x^*) = 1 + x^*(1 - x^*)\,\alpha\beta\,\Delta C'(x^*) \le 0 \tag{A.3}$$

(note that $\Delta C(x^*) = 0$) and $f'(x^*) \in (-1, 0]$ when β is sufficiently low, which ensures that x^* is locally asymptotically stable. By the same arguments, x^* cannot exist for $\alpha < \alpha_2^{TR_2} < \alpha_2^{TR_1}$, which implies $\Delta C(0), \Delta C(1) < 0$ and, by Properties 4 and 5 of Theorem 1, it follows that E_0 is the unique asymptotically stable equilibrium. Moreover, by the same arguments x^* cannot exist for $\alpha_2^{TR_2} < \alpha_2^{TR_1} < \alpha$, which implies $\Delta C(0), \Delta C(1) > 0$ and, by Properties 4 and 5 of Theorem 1, it follows that E_1 is the unique locally asymptotically stable equilibrium. This proves point 1. Let us note that $\frac{dC_1}{dx} < 0$ and $\frac{dC_2}{dx} > 0$, when $\frac{\Phi_1(0)}{LP_1(0)} > \frac{\Phi_1(1)}{LP_1(1)}$ and $\frac{\Phi_2(1)}{LP_2(1)} > \frac{\Phi_2(0)}{LP_2(0)} + k\frac{1+\beta_2}{1+\gamma_{21}}$. Hence, $\Delta C(x)$ is upward sloping and at most an interior equilibrium exists which implies, since $\Delta C(x)$ is a continuous function and downward sloping, $\Delta C(0) < 0 < \Delta C(1)$, that is, both E_1 and E_0 are stable. In this case, $\alpha_2^{TR_1} < \alpha_2^{TR_2}$ and the proof of point 2 is analogous to the one of point 1. Since $\Delta C(x) = 0$ reduces to the solution of a third-degree equation, for $\Delta C(x)$ non-monotonic at most three equilibria can exist and either $\alpha_2^{TR_2} < \alpha_2^{TR_1}$ or $\alpha_2^{TR_1} < \alpha_2^{TR_2}$. Moreover, $\alpha_2 < \min\left\{\alpha_2^{TR_1}; \alpha_2^{TR_2}\right\}$ implies $\Delta C(0) < 0$, therefore E_0 asymptotically stable by Property 5 in Theorem 1, and $\Delta C(1) > 0$ for $\alpha_2 > \max\left\{\alpha_2^{TR_1}; \alpha_2^{TR_2}\right\}$, therefore E_1 locally asymptotically stable by Property 4 in Theorem 1. This proves point 3. □

Proof of Lemma 1. Let us note that $\phi_2 < \phi_2^{off/re}$ implies $C_2(0) < C_1(1)$, and $\phi_2 > \phi_2^{off/re}$ implies $C_1(1) < C_2(0)$. This proves the Lemma. □

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Proof of Corollary 1. Since $\gamma_{21} = \beta_1$, $\gamma_{12} = \beta_2$, $k = 0$, and $\alpha_1 = \alpha_2$ by assumption, solving $C_1(x^*) = C_2(x^*)$ we obtain $x^* = \frac{\phi_2 - c_1 + c_2}{\phi_1 + \phi_2}$. Being $\phi_2 > c_1 - c_2 > -\phi_1$ by assumption, $x^* \in (0, 1)$ is an interior equilibrium, $C_1(1) - C_2(1) = \frac{c_1 + \phi_1 - c_2}{1 + \beta_1} > 0$, and $C_1(0) - C_2(0) = \frac{c_1 - c_2 - \phi_2}{1 + \beta_2} < 0$. Therefore, E_0 and E_1 are unstable equilibria by Theorem 1 and an interior attractor exists which is the interior equilibrium $E_I = x^*$ if the intensity of choice is sufficiently low. Let us further point out that under the parameter condition assumed in the Corollary, the total production cost $C_1(x) + C_2(x)$ is strictly monotone for all $x \in (0, 1)$. Hence, the minimum total production cost is always at one extremum, either $x = 0$ or $x = 1$, despite they are unstable. This proves the Corollary. □

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