

IMF Working Paper

© 1997 International Monetary Fund

This is a *Working Paper* and the author(s) would welcome any comments on the present text. Citations should refer to a *Working Paper of the International Monetary Fund*. The views expressed are those of the author(s) and do not necessarily represent those of the Fund.

WP/97/69

INTERNATIONAL MONETARY FUND

Research Department

Exchange Rate Regimes and Location

Prepared by Luca Antonio Ricci¹

Authorized for distribution by Peter Isard

June 1997

Abstract

This paper investigates the effects of fixed versus flexible exchange rates on firms' location choices and on countries' specialization patterns. In a two-country, two-differentiated-goods monetary model, demand, supply, and monetary (as well as exchange rate) shocks arise after wages are set and prices are optimally chosen. The paper finds that countries are more specialized under flexible than fixed rates, and that the pattern of specialization is not uniquely defined by trade models but depends also on the exchange rate regime. The adoption of fixed exchange rates endogenously increases the desirability of this currency area by reducing the shock asymmetry. These results also shed light on the effects of exchange rate variability on trade.

JEL Classification Numbers: F1; F31; F33; F4; L16; R12.

Keywords: Exchange rate regimes; Location; Specialization; Optimum currency areas.

Author's E-Mail Address: lricci@imf.org

¹I am grateful to Joshua Aizenmann, Richard Baldwin, Olivier Blanchard, Alessandra Casella, Francesco Caselli, Donald Davis, Avinash Dixit, Guy Dumais, Hans Genberg, Jose' Gonzales, Paul Krugman, Philip Lane, Giovanni Maggi, Paul Masson, Jeffrey Sachs, Carmelo Salleo, and Jaume Ventura for helpful discussions and comments. I thank all the participants in conferences or workshops at ASSA 97, CEPR-CUSO, ESEM 96, GIIS, Harvard University, IGIER, La Sapienza University, University of Konstanz, University of Paris-I Panthéon-Sorbonne, and University of Louvain. I am indebted to Edward T. Smith for invaluable help. Generous financial support from the Swiss National Research Funds is gratefully acknowledged. The usual disclaimers apply. The ideas presented in the paper are not necessarily those of the IMF.

	Contents	Page
Summary	3
I.	Introduction	4
II.	The Basic Model (with Demand Shocks)	8
	A. Structure of the model	8
	Uncertainty, timing of actions, and price setting	9
	Preferences and wealth	10
	Market structure and technology	10
	Monetary rule	11
	B. Equilibrium Conditions	11
	Consumer's behavior	11
	Firms' behavior	12
	Equilibrium in the goods and money market	13
	C. Equilibrium in the Absence of Shocks	13
III.	Uncertainty, Incentive to Relocate, and Equilibrium Location	14
	A. Demand Shocks	14
	Fixed exchange rate regime	15
	Flexible exchange rate regime	15
	B. The Incentive to Relocate	16
	Fixed exchange rate regime	16
	Flexible exchange rate regime	17
	C. Equilibrium Location of Firms	17
IV.	Other Sources of Uncertainty	18
	A. Monetary Shocks	18
	Fixed exchange rate regime	18
	Flexible exchange rate regime	19
	B. Supply Shocks	20
	Fixed exchange rate regime	20
	Flexible exchange rate regime	21
	C. Exchange Rate Shocks	22
	Flexible exchange rate regime	22
V.	Note on Price and Wage Flexibility	23
	Price flexibility but wage rigidity	23
	Price and wage flexibility	24
	Summing up	24
VI.	Results and Implications	24
References	29

SUMMARY

This paper investigates the effects of fixed versus flexible exchange rate regimes on the location choices of firms and on the degree of specialization of countries. In a two-country two-differentiated-goods monetary model, demand, supply, and monetary (and exchange rate) shocks arise after wages are set and prices are optimally chosen. When real demand or supply shocks occur, the exchange rate performs an adjustment role for firms located in the country that is more specialized in the goods produced by those firms, but the exchange rate constitutes a factor of disturbance for the other firms. As firms choose *ex ante* the location that offers higher expected profits for their industry, the paper finds that countries are more specialized under flexible than fixed exchange rates. Similar results hold for monetary shocks (and for exogenous exchange rate shocks).

The paper has two major implications. First, the pattern of specialization indicated by any trade model is not unique but depends also on the exchange rate regime. Second, the adoption of a fixed exchange rate regime increases the desirability of such a currency area, as it induces sectoral dispersion of production and consequently reduces the asymmetry of shocks. Interesting implications for the effects of exchange rate variability on trade are also drawn in the paper.

I. INTRODUCTION

This paper² investigates the effects of alternative exchange rate regimes on location choices of firms and on the degree of specialization of countries. It emphasizes the sectoral impact of demand, supply, monetary, and exchange rate shocks³ in the presence of short-run market rigidities. Such an impact affects the expected profits of firms belonging to different sectors in a different way, generating incentives to relocate. We find that countries tend to be more specialized under flexible exchange rates than under fixed rates. This result suggests that the pattern of specialization indicated by any trade model is not unique but depends also on the exchange rate regime. Another important implication follows: the net-benefits that can be expected from the creation of a currency area are endogenous to -and rising with- the institution of the currency area, as the latter induces sectoral dispersion and consequently reduces the degree of asymmetry of shocks.

The core economic mechanism driving this result can be decomposed in three sequential steps: the different effects of the two exchange rate regimes on variability of sales; the relation between variability of sales and expected profits; the incentive to locate where expected profits are higher.

The intuition, for the case of demand shocks, is as follows. Consider a world constituted by two countries (1 and 2) engaging in both intra- and inter-industry trade of two differentiated goods (A and B); country 1 is a net exporter of good A. The world is initially in equilibrium. After prices are chosen, assume a shift of demand from good B to good A. Under fixed exchange rates, the shock affects equally all firms producing the same good, regardless of their location. Under floating, however, currency 1 appreciates, as the shock hits asymmetrically the two countries. The consequent substitution effect reduces the initial increase of demand experienced by firms producing good A in country 1, but generates a further increase in the demand for varieties of good A produced in country 2 (analogously for industry B, provided that we substitute 1 with 2). Therefore, endogenous exchange rate movements provide a partial adjustment for the firms located in the country which is a net exporter of the good they produce, but generate further disturbance for the firms within the same industry located in the net importer country. As a consequence, under a flexible exchange rate regime, firms located in the country relatively specialized in (net exporter of) the good they produce experience a lower variability of sales than their competitors.

²This paper draws on a chapter of my Ph.D. thesis at the Graduate Institute of International Studies (GIIS). Previous drafts have been written while I was Visiting Fellow at the Department of Economics of Harvard University; it has been completed while I was at the University of Konstanz under the HCM program.

³In the first three cases, the exchange rate is endogenous to the occurrence of shocks. For completeness, and to ease the comparison with the previous literature on exchange rate variability and FDI, we present also the case of exogenous exchange rate shocks; such shocks are meant to represent financial shocks due to other reasons than the three sources of shocks already mentioned.

Higher variability of sales results in lower expected profits in the presence of decreasing returns to scale and price rigidities,⁴ as the profit function becomes concave in output. Firms dislike variability of sales also for other reasons, such as the presence of costs of firing workers, due for example to institutional regulations; or bankruptcy costs, such as legal fees; or costs of maintaining stocks of goods in order to smooth excess demands.

Even if price rigidities and shocks eventually fade away, new price rigidities and shocks will arise, and firms should expect the same scenario to occur over time. Under flexible exchange rates, therefore, firms have an incentive to locate in the country which is relatively specialized in the good they produce.⁵ Under fixed exchange rates, however, all firms face the same variability of sales regardless of their location, and no incentive to relocate arises. As a consequence, countries should be more specialized under flexible exchange rates than under fixed rates.

Supply shocks have the same effect as demand shocks. In other words, when real shocks occur under flexible exchange rates, each firm has an incentive to locate in the country whose aggregate shocks to net exports are positively correlated with the firm's shocks, so that the exchange rate would constitute for the firm an instrument of automatic short-run adjustment and not a further disturbance. Given that such a relocation incentive is inexistent under fixed exchange rates, countries tend to be more specialized under flexible than under fixed exchange rates.

Monetary shocks have similar implications. When these shocks arise in a flexible exchange rate regime, firms have an incentive to locate in the country with the largest market share of the good they produce, in order to benefit from a smaller substitution effect, a lower variability of sales, and higher profits. Countries will tend to be more specialized under flexible rates than under fixed rates (where the incentive is inexistent) if the country with the largest market share in one industry is also a net exporter of the varieties produced within such industry.⁶ For completeness, we show that identical conclusions are drawn in the case of exogenous exchange rate shocks, which could be considered as financial shocks that cannot be directly attributed to shocks in fundamentals.

These results have strong implications. When evaluating the pattern of specialization suggested by a trade model, one should take into account also the exchange rate regime. The same set of countries, facing a given comparative advantage, will have a different pattern of

⁴Both assumptions seem reasonable in the short-run, which is the time horizon of the process of adjustment to shocks we consider.

⁵In the absence of a comparative advantage, an equilibrium location pattern under floating is attained only when countries are fully specialized. We will discuss this extreme outcome in Sections III and VI.

⁶This condition is automatically satisfied in our model. When the condition is not satisfied, some additional agglomeration phenomena may occur; such phenomena are currently the object of a separate investigation of ours.

specialization under different exchange rate regimes. Conversely, taking the location of production as exogenous when evaluating changes in exchange rate regimes can be misleading. For example, the creation of a currency area makes countries less specialized, hence shocks less asymmetric, thereby reducing the costs of relinquishing the exchange rate as an instrument of adjustment. This paper may also help understanding the numerous empirical results related to the effects of the exchange rate variability on trade, as we will discuss in the conclusions.

The novelty of our result stems from the integration of basic elements of both trade theory and open macroeconomics. Trade theory usually neglects the existence of short-run market rigidities and assigns no role to the nominal exchange rate; the exchange rate regime is therefore irrelevant for the pattern of specialization. Open macroeconomics deals extensively with market rigidities, but usually views countries as fully specialized (or implicitly producing "aggregates") and does not allow for an analysis of the sectoral impact of exchange rate movements. The interesting synergies arising from the combination of these two theoretical approaches are not often examined.

Location theory has received a renewed attention since Krugman's (1991) "economic geography" approach proposed a simple framework to investigate location as a result of dispersion and concentration forces and to formalize forward and backward linkages⁷ as a source of industrial concentration. These linkages can be derived by introducing trade costs and partial factor mobility in the usual new trade theory setup, based on increasing returns to scale, monopolistic competition, and product differentiation. In the numerous following contributions many aspects were added to the picture, such as intermediate inputs (Krugman and Venables, 1993; Venables, 1996), congestion (from land rent, as in Elizondo and Krugman, 1992; from fix local supply of housing, as in Helpman, 1996); trade policy (Elizondo and Krugman, 1992); taxation and spending (Trionfetti, 1996a); debt policy (Trionfetti 1996b); growth (Martin and Ottaviano, 1996); different infrastructures across locations (Martin and Rogers, 1995). However, new location theory has not yet analyzed the effects of exchange rate regimes on location.

A related literature is focusing on the effects of exchange rate regimes on foreign direct investment (FDI); such literature is however inadequate to investigate the implications for the pattern of specialization. Most of the investigation of firm's optimal choices under exchange rate uncertainty is based on a partial equilibrium analysis of the behavior of a single firm. The main result is that when the exchange rate is more variable a risk averse firm will increase FDI (see Campa and Goldberg, 1993; Goldberg and Koldstad, 1994; Cushman, 1985) or will increase foreign production and decrease foreign sales (see Broll and Zilcha, 1992,⁸ and Broll, Wahl, and Zilcha, 1995). However, this literature usually neglects the

⁷ The "forward linkage" is the incentive of agents who demand final or intermediate goods to locate close to suppliers of these goods; conversely the "backward linkage" is the incentive of suppliers of final or intermediate goods to locate close to the demand for such goods.

⁸ When direct hedging is possible the 'separation result' holds and firm's production and sales
(continued...)

endogenous nature of the exchange rate and, failing to capture the heterogeneity of sectors of production in the economy, it does not allow us to infer how changes in FDI or in foreign production are related to changes in the pattern of specialization. Goldberg and Koldstad (1994) find that a positive correlation between the demand shocks faced by the firm and the depreciations of domestic currency raises FDI. However, such a correlation is exogenous and there is no mention about what correlation (and therefore which behavior) is associated with other domestic firms and with foreign firms. Therefore we cannot infer which is the final equilibrium distribution of production. Aizenmann (1992) develops a two-country model with both real and monetary aspects and finds that under fixed exchange rates both domestic and foreign direct investment are higher than under flexible exchange rate (see Aizenmann (1994), for the implications on the welfare ranking of the two exchange rate regimes). Although his complex model has the merit of avoiding a partial equilibrium approach, countries' productions are homogenous and once again we cannot infer changes in the degree of specialization.

In order to improve upon the existing literature, we develop a two-country two-differentiated-good one-factor monetary model where: countries engage in both inter- and intra-industry trade; uncertainty arises from demand, supply, and monetary shocks; and the exchange rate is determined endogenously. The effectiveness of the exchange rate stems from the fact that countries do not have an identical production structure and that wages are set and prices are optimally chosen before the resolution of uncertainty. Within this framework, we investigate how endogenous movements in the exchange rate affect firms' sales and profits, generating incentives to relocate. In order to pursue such an investigation, we neutralize the backward and forward linkages by giving a mirror-image structure to the two countries and by assuming international factor immobility. The effect of these linkages on location is in fact notorious from the new location theory and we want to focus on the intuition behind the exchange rate effect.⁹

Price rigidities, decreasing returns to scale and international labor immobility allow us to tailor this one period model towards the representation of the **short-run** adjustment to shocks. Although location choices are inherently long-run choices, an extension to a multiperiod framework would not alter qualitatively the results, as long as every period some shocks arise after prices are chosen; similarly, the introduction of tradable financial assets other than money could reduce the size of the incentive to relocate, but would not change the nature of the results (we will discuss again these points in Section VI).

The rest of the paper is structured as follows. Section II describes the basic model with demand shocks. Section III employs the basic model to investigate the adjustment to demand

⁸(...continued)

decisions are independent of exchange rate uncertainty or of risk aversion.

⁹The two effects (from the linkages and from the exchange rates) could obviously be combined, but at high cost of mathematical complexity and with no significant gain in intuition.

shocks, the expected profitability, and the incentives to relocate faced by firms of different sectors within each country, under both fixed and flexible exchange rate regimes. It then infers the equilibrium location pattern under the two regimes. Section IV shows how similar results hold in the case of monetary, supply, and exchange rate shocks. A brief note on price and wage flexibility follows in Section V. Section VI discusses the results and the implications of the paper.

II. THE BASIC MODEL (WITH DEMAND SHOCKS)

A. Structure of the model

This model extends Blanchard and Kiyotaki (1987) to a two-country two-differentiated-good setup.¹⁰ Consider a world constituted of two countries (1 and 2), which are inhabited by the same amount of individuals (L), and produce two types of goods (A and B). Each good is produced in n differentiated varieties (indexed by $i=1, \dots, n$ for good A and by $j=1, \dots, n$ for good B) worldwide, each variety being manufactured by a different firm.¹¹ The only factor of production, labor, is homogenous, immobile across countries, and mobile across industries (this last assumption is not essential).

The two countries have a **mirror-image** production structure:¹² a share η of the n firms in industry A are located in country 1, and the same share η of the n firms in industry B are located in country 2. If $\eta=1/2$, countries would have an identical production structure; $\eta=0$ or $\eta=1$ would imply full specialization; we assume $1/2 < \eta < 1$ so that country 1 (2) is **relatively specialized** in good A (B). We define a **sector** as the part of an industry located in one country; there are therefore four sectors: **A1, A2, B1, B2**.

¹⁰We leave out some of the features of the Blanchard and Kiyotaki's (1987) model. For our purposes, in fact, it is unnecessary to replicate their endogenous wage setting, and therefore to employ differentiated labor supply and to introduce work in the utility function.

¹¹ In order to simplify the exposition of our analysis we maintain as fixed the number of firms in each industry (A or B). This number could be derived endogenously by allowing for free entry and introducing a fix cost in terms of labor. Such addition would leave our analysis unaltered. An *addendum* working out the details can be obtained from the author upon request.

¹²This mirror-image location of firms could be derived endogenously in different ways. In a world with two factors of production unequally distributed across countries one could assume that factors are industry-specific (as in Krugman, 1981) or employed in different proportions in the two industries (as in a standard Heckscher-Ohlin framework). In our one-factor model, one could introduce trade costs and a Ricardian comparative advantage based on productivity differences (as in Ricci, 1997). However, as we will discuss later, our inference on the relocation incentives under different exchange rate regimes would be unaltered. A previous draft contained a comparative advantage based on technological differences, trade costs and product differentiation, as in Ricci (1997): the resulting mathematical complication obscured the intuition and required simulations to present the results.

In Section II we take the degree of specialization (η) for given. In Section III, in order to investigate the incentive to relocate and the equilibrium location structure under different exchange rate regimes we will proceed in three steps. First, in Section III.A, we investigate the effect of demand shocks on firm's sales in each sector for a given location structure (η). In Section III.B, still for a given distribution of firms (η), we derive the incentive to relocate as the difference in expected profits across locations within the same industry. In Section III.C we find the distribution of firms that occurs if firms are allowed to choose the location before any other action takes place (i.e., before wage setting and so on, see below); such equilibrium distribution of firms arise when expected profits are equal for all firms.

Uncertainty, timing of actions, and price setting

Uncertainty arises from demand shocks (in Section IV we will introduce monetary, productivity, and exchange rate shocks).

Before the resolution of uncertainty, workers of each country set the domestic wage (w_k , $k=1,2$) and commit to supply as much labor as demanded by firms at this wage level.¹³ As the initial wage and the associated employment in the absence of shocks are not relevant to our analysis (what matters are the fluctuations around such an initial level), we assume for simplicity that the wage chosen would ensure full employment in the absence of shocks. In full employment, every worker supplies one unit of labor; as shocks arise, every worker supplies more or less of one unit of labor, depending on domestic firms' demand for such a factor.

Firms observe the wage and choose optimal prices as markup over expected marginal costs¹⁴ (see Section II.B).

After the resolution of uncertainty, a new equilibrium in the goods and money markets is reached: taking for given wages and prices, firms choose optimal employment and output levels, consumers choose optimal consumption and money balances, and, under fixed exchange rate regimes, monetary authorities intervene to stabilize the exchange rate. Actual employment fluctuates around the full employment level.

¹³The introduction of domestic monopolistic unions could provide specific microfoundation for the wage setting process, while "transaction costs of frequent price setting and wage negotiations" (Fischer, 1977) may constitute the reason why wages do not respond to shocks; an example based on menu costs can be found in Blanchard and Kiyotaki (1987).

¹⁴Menu costs or costs in the price-setting decision process may constitute the reason why firms do not change the price once shocks are known. As this paper focuses on the adjustment to shocks in the presence of price rigidities and not on the persistence of unemployment associated with price rigidities even in the absence of shocks, introducing microfoundations for price and wage rigidities would just add unnecessary mathematical complication.

PREFERENCES and wealth

All individuals share the same utility function. A representative consumer¹⁵ of country k chooses nominal money balances (m'_k) and consumption of varieties of good A and B (c_{iAk} and c_{jBk} respectively) so as to maximize the following random preferences:

$$U_k = \left(C_{Ak}^\gamma C_{Bk}^{1-\gamma} \right)^\lambda \left(m'_k / P_k \right)^{1-\lambda}, \quad 0 < \gamma < 1, \quad 0 < \lambda < 1$$

with

$$C_{Ak} = \left(\sum_{i=1}^n c_{iAk}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}, \quad C_{Bk} = \left(\sum_{j=1}^n c_{jBk}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}, \quad \sigma > 1$$

where P_k is the true price index of consumption in country k , σ is the elasticity of substitution among varieties of the same good, and γ is a random variable whose initial value is 0.5 and whose percentage change ($\mu_D = d\gamma/\gamma$) is bounded in $(-z_D, z_D)$ with mean 0 and variance u_D^2 .

The nominal wealth of a representative individual of country k (q_k) is the sum of his income (y_k) and of his endowment of domestic currency (m_k). His endowment of money is a fraction $1/L$ of the domestic stock of money, which may vary under fixed exchange rate because of monetary intervention (see below). Each individual supplies labor to domestic firms at the given wage and receives profits from these firms; his income is therefore a share $1/L$ of domestic firms' revenues. Money is the only asset.¹⁶ The consumer's budget constraint is:

$$\sum_{i=1}^n p_{iA}^k c_{iAk} + \sum_{j=1}^n p_{jB}^k c_{jBk} + m'_k = q_k \equiv m_k + y_k$$

where p_{iA}^k and p_{jB}^k are the prices of variety i of good A and of variety j of good B, measured in the currency of the consumer's country k .

Market structure and technology

The market structure is the usual large group monopolistic competition based on Dixit-Stiglitz (1977) and often adopted in trade theory thereafter (see Helpman and Krugman, 1985). In order to introduce price rigidities, however, we assume that firms play Bertrand¹⁷

¹⁵As agents of different countries may face different prices and wealth, we need to distinguish them.

¹⁶Money in the utility function in a one period model is conceptually an asset and technically a good.

¹⁷We assume no free entry for simplicity. As already explained (see the second footnote in

before the resolution of uncertainty and, taking for given the chosen prices, choose optimal employment after the realization of the shocks.

Production functions are identical for all firms and exhibit diminishing returns to labor. The output (x_{ck}) of a typical firm¹⁸ producing a variety of good c ($c=A,B$) in location k ($k=1,2$) is given by:

$$x_{ck} = D_c l_{ck}^\alpha$$

where D_c is the productivity level of industry c , l_{ck} is the employment of such a firm, and α is a measure of the returns to scale. Decreasing returns to scale are ensured by $0 < \alpha < 1$. We assume that $\alpha = .5$; such assumption is not essential, but allows for extensive mathematical simplifications. In Sections II and III we assume that $D_c = 1$ for both industries; in Section IV we will allow for productivity shocks.

Monetary rule

Monetary authorities are not allowed to pursue discretionary policies. In a fixed exchange rate regime, they are committed to adjust money supplies (M_k) in order to equilibrate the money market and eliminate any pressure on the exchange rate:

$$\frac{dM_k}{M_k} = v_{FIXk} \quad \forall k=1,2$$

In a flexible exchange rate regime monetary authorities abstain from such intervention and let the exchange rate adjust the money market and the trade balance. It is irrelevant to our results whether the fixed exchange rate regime is managed symmetrically or asymmetrically,¹⁹ we choose to solve the model for the symmetric case.

B. Equilibrium Conditions

Consumers' behavior

Consumers observe the prices set by firms and, **after the resolution of uncertainty**, make their optimal choices. The solution to the consumer's maximization problem implies that individuals' demand for money, expenditure on good A, and expenditure on good B are respectively a share $(1-\lambda)$, $\lambda\gamma$, and $\lambda(1-\gamma)$ of their wealth. As all individuals of one country

¹⁷(...continued)

Section II.A), endogenizing the number of firms would not alter the result.

¹⁸All firms of the same sector ck always face the same situation and we do not need to distinguish among them.

¹⁹ In fact, in both cases the variability of sales is the same for all firms.

face the same prices and have the same homothetical utility function, we can easily derive the aggregate demands of country k for money (M'_k) and for each variety of good A produced in country f (A_{fk} , $f=1,2$) (the expressions for good B can be derived analogously):

$$A_{11} = \frac{P_{A1}^{-\sigma}}{P_{A1}^{1-\sigma}} \gamma \lambda Q_1 \quad ; \quad A_{21} = \frac{(e P_{A2})^{-\sigma}}{P_{A1}^{1-\sigma}} \gamma \lambda Q_1 \quad , \quad M'_1 = (1-\lambda) Q_1$$

$$A_{12} = \frac{(p_{A1}/e)^{-\sigma}}{P_{A2}^{1-\sigma}} \gamma \lambda Q_2 \quad ; \quad A_{22} = \frac{P_{A2}^{-\sigma}}{P_{A2}^{1-\sigma}} \gamma \lambda Q_2 \quad , \quad M'_2 = (1-\lambda) Q_2$$

with

$$P_{A1} = \left(n_{A1} P_{A1}^{1-\sigma} + n_{A2} (e P_{A2})^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \quad ; \quad P_{A2} = \left(n_{A1} (p_{A1}/e)^{1-\sigma} + n_{A2} P_{A2}^{1-\sigma} \right)^{\frac{1}{1-\sigma}} = P_{A1} / e$$

$$Q_k = n_{Ak} P_{Ak} x_{Ak} + n_{Bk} P_{Bk} x_{Bk} + M_k = L q_k \quad \forall k=1,2$$

where Q_k is the aggregate wealth of country k, P_{Ak} is true price index of good A in country k, e is the exchange rate defined as units of currency 1 for one unit of currency 2, and n_{ck} is the number of varieties of good c produced in country k. Under fixed exchange rates, only demands and wealth are subject to uncertainty; in a flexible exchange rate regime, also the exchange rate and the true price indexes are affected by the shocks. Consumers of different countries demand the same variety in different amounts when the exchange rate differs from one or when (nominal and real) wealth differs across countries.

Firms' behavior

Before the resolution of uncertainty, a typical firm of sector ck takes the wage and other firms' behavior as given and chooses its price (p_{ck} in local currency) so as to maximize expected profits (π_{ck}):

$$E [\pi_{ck}] = E [p_{ck} x_{ck}^d - w_k l_{ck}] = E \left[p_{ck} x_{ck}^d - w_k \left(\frac{x_{ck}^d}{D_c} \right)^{\frac{1}{\alpha}} \right] \quad \forall c=A,B \quad k=1,2$$

where E is the expectation operator, w_k is the wage prevailing in country k, and x_{ck}^d is the demand for one variety of good c produced in country k:

$$x_{Ak}^d = A_{k1} + A_{k2} \quad , \quad x_{Bk}^d = B_{k1} + B_{k2} \quad \forall k=1,2$$

The optimal price (p_{ck}) is therefore set as a markup over expected marginal cost:

$$p_{ck} = \frac{\sigma}{\sigma-1} E \left[\frac{w_k}{\alpha} D_c^{-\frac{1}{\alpha}} x_{ck}^{\frac{1-\alpha}{\alpha}} \right] = \frac{\sigma}{\sigma-1} E \left[\frac{w_k}{\alpha} \frac{l_{ck}^{1-\alpha}}{D_c} \right] \quad \forall c=A,B \quad k=1,2$$

where σ approximates, for n large enough, the perceived elasticity of demand.

After the resolution of uncertainty, firms choose optimal employment. As prices and wages are now given, **the profit function is rising in output** (around the initial equilibrium) and the firms will find it optimal to satisfy demand.²⁰ **The profit function is also concave in output**, implying that **firms dislike variability of sales**.²¹

Equilibrium in the goods and money market

Equilibrium in the goods market requires:

$$x_{Ak} = A_{k1} + A_{k2} \quad , \quad x_{Bk} = B_{k1} + B_{k2} \quad \forall k=1,2$$

Equilibrium in the money market (equivalent to balanced trade) is ensured by exchange rate movements, in a flexible exchange rate regime, and by residual intervention of the monetary authorities (v_{FIXK}), in a fixed exchange rate regime.

C. Equilibrium in the Absence of Shocks

In the absence of shocks, both sectors (A and B) face the same labor productivity and receive an identical aggregate expenditure, while both countries have the same money stock:

$$\gamma = 1-\gamma = .5 \quad ; \quad D = 1 \quad ; \quad M_1 = e M_2$$

The only difference between the two countries is then given by their specular pattern of specialization (η). In equilibrium, in fact, both countries have the same wage, aggregate income, and aggregate wealth. All firms employ the same amount of labor, produce the same output, and charge the same price as markup over the same marginal cost evaluated at the firm's equilibrium employment level. As prices are equal, an identical share of expenditure will be allocated to each variety. Every consumer will consume all varieties in the same amount. Full employment is ensured by the wage level.

²⁰This is not true, however, for large increases in demand, which may be satisfied only at a marginal cost higher than the price. We rule out such possibility by assuming that the shocks are opportunely bounded.

²¹As we will discuss later, if prices are flexible, the profit function is linear in sales and firms are indifferent to the variability of sales.

From the Sections II.A and II.B we obtain, after normalizing the exchange rate and the price of each variety to 1:

$$p = e = 1$$

$$x = l^{\frac{1}{2}} = \left(\frac{L}{n} \right)^{\frac{1}{2}} = \frac{\lambda}{1-\lambda} \frac{M^R}{2n}$$

$$w = \frac{\sigma-1}{\sigma} \frac{1}{2x}$$

$$\pi = \frac{\sigma+1}{2\sigma} x$$

where M^R is the equilibrium world real stock of money.

III. UNCERTAINTY, INCENTIVE TO RELOCATE, AND EQUILIBRIUM LOCATION

In this section we first investigate how demand shocks affect firm's sales in each sector, taking for given the location structure (η) (Section III.A). We then analyze the incentive to deviate from such distribution of firms (η) by comparing across locations the expected profits of firms belonging to the same industry (Section III.B). Finally (Section III.C), we find the distribution of firms that occurs if firms are allowed to choose the location before any other action takes place.

A. DEMAND SHOCKS

We now perform a comparative static exercise to identify the effects of a change in the expenditure share between good A and B (μ_D). To preserve the concavity of the profit function, we do not linearize the production function.

As already described, before shocks are known, wages are set at the same level (w) in both countries, and prices are chosen as mark-up over expected marginal costs. As marginal cost is linear in output, whose expected value corresponds to its level in the absence of shocks, **all firms choose the same price**, equal to the certainty price, independently of their variability of output. Again we normalize this price to 1 ($p_{ck}=1, \forall c=A,B k=1,2$). Before shocks arise, therefore, the economy is described by the same set of relations that characterize the equilibrium in the absence of shocks (Section II.C). Assume now a shift in demand.

Fixed exchange rate regime

Under fixed exchange rates, the only effect is the direct demand effect of the change in expenditure shares. For example, in the case of a demand shift from B to A, all firms producing A (independently of where they are located) face the same rise in demand, and all firms producing B face the same fall in demand. The new goods market equilibrium is:

$$X_{Ak} = \mu_D \quad , \quad X_{Bk} = - \mu_D \quad \forall k=1,2$$

where $X_{ck} = dx_{ck}/x_{ck}$ is the percentage change in output of a typical firm producing good c in country k. The money market (hence the trade balance) is equilibrated by intervention of monetary authorities. Sectoral employment follows production.

Flexible exchange rate regime

The direct demand effect deriving from the change in tastes is now accompanied by the substitution effect due to the exchange rate adjustment. There is in fact an appreciation of the currency of the country (say 1), which is relatively specialized in the good (say A) whose demand rises. Such change in the exchange rate will induce consumers to substitute away from production of country 1 and in favor of production of country 2. The exchange rate movement represents therefore a **partial adjustment** for sectors A1 and B2, but a **further disturbance** for sectors A2 and B1. In fact, firms producing A in 1 will see the initial increase in demand dampened by the exchange rate appreciation; on the other hand, firms producing A in 2 will see the initial increase in demand enhanced by the exchange rate depreciation (similar reasoning with opposite locations holds for industry B). The goods and money market equilibria require:

$$\varepsilon = - 2 (2\eta - 1) z \mu_D$$

$$X_{ck} = g_{ckD} \mu_D \quad \forall c=A,B \quad k=1,2$$

where $\varepsilon = de/e$, and

$$z = \frac{1}{1 + 4\eta(1-\eta)(\sigma-1)}$$

$$0 < g_{A1D} = - g_{B2D} = 2 (1-\eta) \sigma z < 1$$

$$g_{A2D} = - g_{B1D} = 2 \eta \sigma z > 1$$

Note that **the exchange rate responds more to a given shock when countries are more specialized** (higher η). This is because the exchange rate movement becomes both more necessary and less effective in the adjustment: in fact, the same shock is associated with larger

trade and monetary imbalances, while the substitution effect induced by the exchange rate grows smaller because of the limited leverage that can be exerted on the small sector of each country. As intuitive, when countries have an identical production structure ($\eta=1/2$), they face symmetric shocks and the exchange rate is completely ineffective: the equilibrium is identical to the one under fixed exchange rates ($\epsilon=0, X_{Ak} = -X_{Bk} = \mu_D$).²² Conversely, when countries are fully specialized ($\eta=1$, implying that sectors A2 and B1 do not exist anymore), the exchange rate brings full adjustment, as it generates the relative price movement required to reach a new equilibrium at unchanged quantities ($\epsilon = -2\mu_D, X_{Ak} = X_{Bk} = 0$).

B. The Incentive to Relocate

Firms of a given industry have an incentive to choose ex ante the location that offers the highest expected profits for that industry.²³ Starting from a generic initial distribution of location (described by η , see Section II.A) we investigate such an incentive under the two exchange rate regimes. Within each industry, the **incentive to relocate** from country k' to country k'' can be measured by the difference between the expected profits for that industry in country k'' and the expected profits for the same industry in country k'.

Fixed exchange rate regime

In such a regime all firms experience the same variability of output and therefore the same expected profits:

$$E [\pi_{ck}] = x - w E [x (1+X_{ck})]^2 = \pi - w x^2 u_D^2$$

where x and π are respectively the level of output and profits that would prevail in the absence of shocks. The larger the variability of the shocks (u_D^2) the lower the expected profits, because the profit function is concave in output (see Section II.B).

As all firms face ex ante the same expected profits, **in a fixed exchange rate regime there is no incentive to choose a different location.**

²²This situation corresponds to the Mundell's (1961) example of two countries (North and South) sharing equally two "product-regions" (East and West). These two countries constitute an optimal currency area even in the absence of international factor mobility, because of the ineffectiveness of the exchange rate.

²³Such reasoning is mostly appropriate when firms observe the exchange rate regime before choosing their location. When firms face a change in exchange rate regime, the incentive to relocate should be adjusted to account for relocation costs. This quantitative adjustment, however, would leave unaltered the qualitative nature of the results.

Flexible exchange rate regime

By confronting the coefficients g_{ckD} derived in the previous section, we can infer that firms located in the country relatively specialized in their industry (i.e. firms producing varieties of A in 1 or of B in 2) face a lower variability of sales and higher expected profits than firms of the same industry located in the other country (A in 2 or B in 1):

$$E[\pi_{ck}] = x - w E[x(1+X_{ck})]^2 = \pi - w x^2 g_{ckD}^2 u_D^2$$

Therefore, in a flexible exchange rate regime, firms have an incentive to locate in the country relatively specialized in the good they produce: firms producing A have an incentive to locate in 1 while firms producing B have an incentive to locate in 2²⁴. Because of the mirror-image production structure, the "size" (absolute value) of the incentive to relocate is the same for the firms of the two industries. Such incentive to relocate (IR_D , where the subscript indicates the source of the shocks: demand) is therefore given by:

$$IR_D = E[\pi_{a1}] - E[\pi_{a2}] = E[\pi_{b2}] - E[\pi_{b1}] = w x^2 4 (2\eta - 1) \sigma^2 z^2 u_D^2$$

The incentive increases with the degree of specialization (η) and with the variance of the shocks (u_D^2). When countries are more specialized (higher η), the exchange rate moves more (see Section III.A) and generates a larger adjustment for the sectors of specialization of each country (A1, B2), reducing their already low variability of sales and raising the expected profits. The exchange rate movement enhances, however, the effect of the shocks on the sales of the other sectors (A2, B1), whose firms face even lower expected profits.

C. Equilibrium Location of Firms

If firms choose their location before any other action (and shock) takes place, an equilibrium location pattern arises when expected profits are equal for all firms (as no firm would have an incentive to choose a different location). From the previous Section III.B, we can infer that in this simple model the **equilibrium location of firms under fixed exchange rates is given by the initial distribution of firms, while under floating is given by full specialization**. This extreme result is due to the exogenous nature of the initial distribution of firms (η). In Section VI we discuss how the introduction of a comparative advantage would prevent such extreme outcome while preserving the main result that countries are more specialized under flexible than under fixed exchange rates.

²⁴Even if our framework is static and price rigidities will eventually fade away, it is conceivable that the same incentive to relocate would arise in an intertemporal framework where our static scenario repeats over time: every period, wages and prices are chosen before new shocks are known; price rigidities and shocks last one period. We will come back to this point (see section VI).

IV. OTHER SOURCES OF UNCERTAINTY

In this section we investigate the effects of monetary, productivity, and exchange rate shocks.

A. Monetary Shocks

This section is particularly interesting both because a substantial amount of short-run exchange rate variability is of monetary nature, and because on a first thought one would not envision **sectoral** relocation effects arising from monetary shocks.

Assume that the economy is now disturbed by national monetary shocks which take the form of percentage changes in the initial money stock ($\mu_{Mk} = dM_k/M_k$) and are bounded in $(-z_M, z_M)$ with mean 0 and variance u_M^2 (we assume equal variance across countries). Money supply of country **k** would now change both because of monetary shocks (μ_{Mk}) and, in a fixed exchange rate regime, because of the residual authorities' intervention (v_{FIXk}) to equilibrate the money market:

$$\frac{dM_k}{M_k} = \mu_{Mk} + v_{FIXk} \quad \forall k=1,2$$

As for the case of demand shocks, firms' expected marginal cost is equal to its value in the absence of shocks and therefore the initial equilibrium is again described by the set of equations presented in Section II.C.

Fixed exchange rate regime

Any change in money stock is reflected into an equal change in expenditure on both goods, independently of the country in which the shock originated. All firms experience the same change in sales, hence the same variability of sales and the same expected profits:

$$X_{ck} = (\mu_{M1} + \mu_{M2}) / 2 \quad \forall c=A,B \quad k=1,2$$

$$E[\pi_{ck}] = x - w E[x(1+X_{ck})]^2 = \pi - w x^2 u_M^2 (1+\rho_M) / 2$$

where ρ_M is the coefficient of correlation between the monetary shocks of the two countries, and u_M^2 represents their common variance.

Again, under fixed exchange rates, there is no incentive to choose a different location and the initial distribution of firms is an equilibrium.

Flexible exchange rate regime

In addition to the wealth effects there is the substitution effect associated with the depreciation of the currency which has become relatively more abundant. Such exchange rate movement induces an expenditure shift across countries. Each firm located in the country which accommodates the largest market share of the good the firm produces will bear a smaller share of the expenditure shift than its foreign competitor. This effect would persist under much more general assumptions than the one characterizing our model: what is required is that the elasticity of substitution across varieties of the same good is larger than the elasticity of substitution across varieties of different goods. The equilibrium in the goods and money market is given by:

$$\varepsilon = z (\mu_{M1} - \mu_{M2})$$

$$X_{ck} = (\mu_{M1} + \mu_{M2}) / 2 + g_{ckM} (\mu_{M1} - \mu_{M2}) \quad \forall c=A,B \quad k=1,2$$

$$g_{AIM} = - g_{B2M} = [1 + 2 (1-\eta) (\sigma-1)] z / 2$$

$$g_{B1M} = - g_{A2M} = [1 + 2 \eta (\sigma-1)] z / 2 > g_{AIM}$$

It is easy to check that $dQ_k/Q_k = dM_k/M_k$, implying that flexible rates bottle in domestic monetary shocks and, equivalently, insulate each country from foreign monetary shocks. However, such aggregate outcome hides sectoral differences: firms will in general face a variability of sales which is either higher or lower than the variability of domestic monetary shocks. In fact, within each industry, firms located in the country relatively specialized in that industry (i.e., producing A in 1 or B in 2) face a lower variability of sales and higher expected profits.²⁵

$$E [\pi_{ck FLEX}] = x - w E [x (1 + X_{ck})]^2 = \pi - w x^2 u_M^2 [1 + \rho_M + 4g_{ckM}^2 (1 - \rho_M)] / 2$$

As in the case of demand shocks, firms have an incentive to locate in the country relatively specialized in the good they produce; such incentive (IR_M) rises with the degree of specialization (η) and with the variance of monetary shocks (u_M^2), and decreases with the correlation of the shocks (ρ_M):

²⁵Sufficient condition for this result to hold in a more general trade model is that the country with the largest market share of one good is also a net exporter of that good. In a separate work we investigate also the additional agglomeration effect arising if this condition is not satisfied.

$$IR_M = w x^2 2 (2\eta-1) (\sigma-1) \sigma z^2 u_M^2 (1-\rho_M)$$

As in Section III, under floating, the only equilibrium location patten is full specialization.

B. Supply Shocks

We now show that productivity shocks are similar to demand shocks in their sectoral effects on sales and profits, and therefore in the associated incentive to relocate.

The productivity of industry c (D_c) takes initially the level of 1 and its (absolute and percentage) change ($\mu_{sc}=dD_c$) is bounded in $(-z_s, z_s)$ with mean 0 and variance u_{sc}^2 . We introduce a **monetary rule** justified by the presence of price rigidities: monetary authorities adjust domestic money supply (u_{sk}) by the change in average domestic productivity in order to accommodate changes in expenditure.²⁶ Money supply of country k would now change because of the accommodation (u_{sk}) and, in a fixed exchange rate regime, because of the intervention (u_{FIXk}) in order to equilibrate the money market:

$$\frac{dM_k}{M_k} = v_{Sk} + v_{FIXk} \quad \forall k=1,2$$

$$v_{S1} = \eta\mu_{SA} + (1-\eta)\mu_{SB} \quad , \quad v_{S2} = (1-\eta)\mu_{SA} + \eta\mu_{SB}$$

In order to enlighten the intuition without entering heavy mathematical complexity, we neglect that under flexible exchange rates firms of different sectors should choose different prices.²⁷ We simply assume that each firm sets the price at its optimal level in the absence of shocks, so that the initial equilibrium is described by the set of equations presented in Section II.C and is therefore equal to the **usual initial equilibrium** for the cases of both demand and monetary shocks. Let us now describe the effects of productivity shocks.

Fixed exchange rate regime

The monetary accommodation allows expenditure on all goods to change by the world average productivity growth. At initial employment levels, firms in the industry whose productivity has risen relatively more would be in excess supply of goods; they therefore

²⁶In the absence of such monetary rule, productivity shocks would have no effect on output (but only on employment). The expected size of each accommodation is zero, as the changes in productivity have a zero mean.

²⁷Marginal costs is no more linear in shocks (as it was, instead, with demand and monetary shocks), and firms of different sectors face different variability of sales under flexible rates.

reduce employment. Conversely for the other sector. As usual under fixed exchange rate regime, **no incentive to relocate** arises, and **the initial location structure is an equilibrium**: all firms experience in fact the same variability of sales and expected profits:

$$X_{ck} = (\mu_{SA} + \mu_{SB}) / 2 \quad \forall c=A,B \quad k=1,2$$

$$E [\pi_{ck}] = x - w E [x (1+X_{ck}-\mu_{Sc})]^2 = \pi - w x^2 (u_{SA}^2 + u_{SB}^2 - 2\rho_S u_{SA} u_{SB}) / 4$$

Flexible exchange rate regime

The country whose average productivity rises relative to the one of the other country experiences a depreciation of its currency. The consequent substitution effect eases the adjustment of firms located in the country relatively specialized in the good they produce (i.e., firms belonging to sectors A1 and B2), as it helps absorbing their (positive or negative) excess supply and reduces their need for a change in employment. The same substitution effect, however, constitutes an element of further disturbance for the other firms (belonging to sectors A2 and B1), by enhancing their excess supply and employment change. The similarity with the demand shocks case is striking. In the new goods and money market equilibrium, the changes in output due to changes in employment are:

$$X_{ck} - \mu_{Sc} = g_{ckS} (\mu_{SA} - \mu_{SB}) \quad \forall c=A,B \quad k=1,2$$

$$0 < g_{B2S} = -g_{A1S} = (1-\eta) \sigma z < \frac{1}{2}$$

$$g_{B1S} = -g_{A2S} = \eta \sigma z > \frac{1}{2}$$

Within each industry, firms located in the country relatively specialized in that industry experience a lower variability of sales and higher expected profits:

$$E [\pi_{ck FLEX}] = x - w E [x (1 + X_{ck} - \mu_{Sc})]^2 = \pi - w x^2 g_{ckS}^2 (u_{SA}^2 + u_{SB}^2 - 2\rho_S u_{SA} u_{SB})$$

The usual incentive to relocate arises. It increases with the degree of specialization (η) and with the variances of the productivity shocks (u_{Sc}^2); it decreases with the correlation of the shocks (ρ_S):

$$IR_S = w x^2 (2\eta-1) \sigma^2 z^2 (u_{SA}^2 + u_{SB}^2 - 2\rho_S u_{SA} u_{SB})$$

Again, in a flexible exchange rate regime, the equilibrium location of firms is given by full specialization.

C. Exchange Rate Shocks

We now show that exogenous exchange rate shocks induce incentives to relocate and equilibrium location patterns which are similar to those caused by monetary shocks. Obviously, in this section the exchange rate is not an endogenous variable and the only exchange rate regimes considered is the flexible one. Exchange rate shocks are meant to represent the high short run volatility of the exchange rate, which is not due to precise shifts in fundamentals, but to other factors (such as changes in the political environment, or anticipation of future policy-changes which not necessarily occur, and so on). Ideally, any exchange rate movement is endogenous and should be formalized as such. Having already formalized three sources of endogenous exchange rate adjustments (demand, supply and monetary shocks) we find it nonetheless useful to present this simple case for completion.

Flexible exchange rate regime

Assume that the economy is now disturbed by an exchange rate shock which take the form of percentage changes in the exchange rate level ($\mu_{Ek} = de_k/e_k$) and are bounded in $(-z_E, z_E)$ with mean 0 and variance u^2_E .

As in the case of monetary shocks, the exchange rate movement induces an expenditure shift across countries. Each firm belonging to the small sector of each country will bear a larger share of such an expenditure shift than a firm located in the country specialized in the good they produce. The equilibrium in the goods market²⁸ requires:

$$X_{ck} = g_{ckE} \mu_E \quad \forall c=A,B \quad k=1,2$$

$$g_{A1E} = -g_{B2E} = [\sigma (1-\eta) + (\eta-1/2)]$$

$$g_{B1E} = -g_{A2E} = [\sigma \eta - (\eta-1/2)] \quad > \quad g_{A1E} = -g_{B2E}$$

Within each industry, firms located in the country relatively specialized in that industry (i.e. producing A in 1 or B in 2) face a lower variability of sales and higher expected profits:

$$E [\pi_{ck \text{ FLEX}}] = x - w E [x (1 + X_{ck})]^2 = \pi - w x^2 g_{ckE}^2 u_E^2$$

Firms have an incentive to locate in the country relatively specialized in the good they produce; such incentive (IR_E) rises with the degree of specialization (η) and with the variance of (u^2_E):

²⁸ In this section, due to the exogeneity of the exchange rate, we obviously neglect the money market equilibrium and the trade balance.

$$IR_E = w x^2 (2\eta-1) (\sigma-1) \sigma u_E^2$$

As in Section III, under floating, the only equilibrium location pattern is full specialization.

V. NOTE ON PRICE AND WAGE FLEXIBILITY

If prices are flexible, the profit function is linear in sales ($p_{ck} x_{ck}$), both with fixed and flexible wages.²⁹ In fact, recalling the optimal pricing rule (in actual terms), we obtain:

$$w_k l_{ck} = \alpha \frac{\sigma-1}{\sigma} p_{ck} x_{ck} \quad \text{hence} \quad \pi_{ck} = \left(1 - \alpha \frac{\sigma-1}{\sigma} \right) p_{ck} x_{ck}$$

It is, however, reasonable to think that concavity in the production function and short-run price rigidities is not the only reason why **firms dislike variability of sales**. In fact, we already mentioned in the introduction other reasons such as firing, inventory, and bankruptcy costs. We can also conceive that firms would behave as risk averse if the owners are risk averse and face incomplete financial markets, or if managers are risk averse and face imperfect labor market or get non-marketable payoffs (such as satisfaction, reputation, . . .). In all these cases, firms would still be sensitive to the variability of sales. We therefore briefly discuss the adjustment to demand and monetary shocks³⁰ in two cases. **Case 1: price flexibility but wage rigidity. Case 2: price and wage flexibility.**

Price flexibility but wage rigidity

Fixed exchange rates. With demand shocks, prices and quantities change, in absolute value, by the same percentage for all varieties. With monetary shocks, prices and quantities change equally for all varieties. Therefore, in the occurrence of both kinds of shocks, all firms face the same variability of sales, and no incentive to relocate arises.

Flexible exchange rates. With demand shocks, the country which is a net exporter of the good whose demand rises experiences a depreciation of its currency. With monetary shocks, the currency which becomes relatively more abundant depreciates. In both cases, the

²⁹ Note that this outcome is independent of our choice of $\alpha=0.5$.

³⁰With flexible prices, the adjustment to supply shocks is trivial. Independently of the rigidity in wages and of the exchange rate regime, price movements fully adjust the productivity shocks (in the presence of price flexibility, it is no more reasonable to assume that monetary authorities accommodate the shocks). All new levels of output at initial employment levels are demanded at new prices. All firms face zero variability of sales and have the same profits.

usual sectoral pattern of variability of sales occurs, and firms have the usual incentive to locate in the country relatively specialized in the good they produce.

Price and wage flexibility

In this case, monetary shocks involve only nominal adjustment and do not induce relocation incentives, independently of the exchange rate regime. We therefore discuss the occurrence of demand shocks.

Fixed exchange rates. The country specialized in the good whose demand rises experiences a wage increase to restore full employment. Vice versa for the other country. Such relative wage adjustment is incorporated into the optimal prices and generates a substitution effects similar to the one arising under "flexible" exchange rates with price rigidities (see Section III.A): hence firms producing A in 1 and B in 2 experience a lower variability of sales than other firms. For the first time, an incentive to relocate arises under a fixed exchange rate regime, and it is of the same kind usually associated with floating rates: firms prefer to locate in the country relatively specialized in the good they produce.

Flexible exchange rates. The monetary disequilibrium induced by the relative change in national nominal incomes is no more corrected by intervention of monetary authorities. The relative change in money stocks required to restore equilibrium must therefore occur through an exchange rate adjustment.³¹ The difference in the sectoral variability of sales already induced by the relative wage adjustment (as under fixed exchange rates) is enhanced by the new substitution effect. The incentive to relocate is therefore stronger than under fixed exchange rates.

Summing up

We conjecture that demand and monetary shocks in case 1 should give the usual result: under flexible rates, firms would like to locate in the country specialized in the good they produce; under fixed rates such an incentive is inexistent. Demand shocks in case 2 should generate this same incentive under both regimes, the one under flexible rates being stronger.

VI. RESULTS AND IMPLICATIONS

This paper finds that fixed and flexible exchange rate regimes are associated with different location incentives when demand, supply, monetary, and exchange rate shocks³² arise

³¹Note that even with fully flexible prices and wages, the exchange rate has to adjust. In fact, no change in the prices of goods can generate a relative change in national money stocks.

³²The case of exchange rate shocks is just presented for completeness and to ease the

in the presence of short run price rigidities. For all sources of uncertainty, countries tend to be more specialized under flexible exchange rates than under fixed exchange rates.

In fact, when real shocks occur, flexible exchange rates both provide a partial adjustment to the firms located in the country whose aggregate shocks to net exports are positively correlated with the firm's shocks, and generate further disturbance to the other firms. As a consequence, under flexible rates, the firms of a given industry which are located in the country relatively specialized in that industry experience lower variability of sales and higher expected profits than their competitors. Therefore, flexible rates give to each firm an incentive to locate in the country relatively specialized in the good the firm produces. Given that such a relocation incentive is inexistent under fixed exchange rates, countries tend to be more specialized under flexible than under fixed exchange rates.

When financial shocks³³ occur under flexible rates, firms of a given industry have an incentive to locate in the country that has the largest market share of that industry, in order to benefit from a smaller substitution effect, a lower variability of sales, and higher profits. Such location incentive drives larger country specialization under flexible rates than under fixed rates (where the incentive is inexistent) if the country with the largest market share in one industry is also a net exporter of the varieties produced within such industry.³⁴

For all sources of uncertainty, the incentive to locate differently under the two regimes rises with the degree of specialization of countries and with the variance of shocks. It decreases with the correlation of real shocks between industries or of monetary shocks between countries.

We adopt a static framework with short-run price rigidities to investigate a decision, the choice of location, whose horizon goes well beyond the short run.³⁵ However, it seems likely that a dynamic extension of our model would not alter the nature of our findings, as

³²(...continued)

comparison with the previous literature on FDI and exchange rate variability (see the introduction), as the exchange rate should always be determined endogenously. These shocks are meant to represent financial shocks that cannot be directly attributed to shocks in fundamentals (see Section IV.C).

³³Domestic or foreign monetary shocks or exogenous exchange rate shocks.

³⁴Such condition is automatically satisfied in our simple model. In a separate work, we are also investigating the interesting implications arising when the condition is not fulfilled.

³⁵Our model neglects the existence of financial assets other than money. However, the qualitative nature of our results would still hold as long as contingent claims market are incomplete (hence, hedging, as long as imperfect, would not alter qualitatively the result). In the presence of perfect international equity markets, the results would hold (for supply and monetary shocks) if firms maximize expected profits. Such (or more restrictive) assumptions are commonly adopted in the analysis of exchange rate regimes or of location choices.

long as every period the temporal order of wage setting, resolution of uncertainty, and trading is preserved. In fact, one can conceive a version based on **intertemporal optimization** where the scenario we outlined repeats over time: every period, wages are set and prices are optimally chosen before the resolution of uncertainty; shocks last one period (permanent shocks would otherwise be adjusted at the end of the period they occurred). In the absence of financial capital flows across countries, the results would be equivalent to the ones derived in our static model, once adjusted for net present value calculations. In the presence of **capital mobility**, both the exchange rate movements and the incentive to relocate would be dampened. In either case, the qualitative nature of our conclusions would still hold.

Also the introduction of FDI should not alter the results. In fact, not only the location choice of the main firm, but also of its foreign subsidiaries would be subject to the same incentives we described. In terms of our initial example (see the introduction), under flexible rates, a firm producing A would not only have an incentive to locate the main headquarter in country 1, but would also find little incentive to open a subsidiary in country 2.

In the **absence of price rigidities**, the profit function is linear in sales, whose variability becomes indifferent to the firm. If however one would account for other reasons why firms care of variability of sales (such as firing, inventory, and bankruptcy costs), it should be inferred that flexible exchange rates are still associated with larger specialization, even in the presence of price flexibility (see Section V).

Our findings imply that the pattern of specialization indicated by any trade model is not unique but depends also on the exchange rate regime. If our model were to be taken literally, in a fixed exchange rate regime any initial location structure (η) would be an equilibrium distribution of firms (i.e. a distribution of firms such that firms have no incentive to relocate); under flexible exchange rates, however, an equilibrium distribution of firms would arise only when countries are fully specialized ($\eta=0$, or $\eta=1$). A more realistic scenario could be obtained by introducing a **comparative advantage** or other trade theoretical justifications for the initial location pattern (see Section II.A). In such an extension the equilibrium location distribution under fixed exchange rates would be dictated only by the comparative advantage. Under flexible exchange rates, however, the occurrence of shocks in the presence of price rigidities would still generate the described incentive to deviate from the location distribution induced by the comparative advantage: the **equilibrium location distribution** could therefore be determined by weighing, for the marginal firm, the incentive to relocate in order to benefit from the adjustment role of the exchange rate, against the efficiency loss associated with the departure from the location dictated by the comparative advantage. It is curious to note that in the presence of shocks and price rigidities, the fixed exchange rate regime, and not the flexible one, gives the same location structure as a trade model which neglects all short run rigidities and where money is a veil.

Extensive efforts have been devoted to the empirical investigation of the effects of **exchange rate variability on trade** (see, for example, Dell'Ariccia, 1996; Frankel and Wei, 1995; Gagnon, 1993; Perée and Steinherr, 1989; De Grauwe, 1988; IMF, 1984). Partial equilibrium analysis of the behavior of a firm with concave utility (out of profit) function

would suggest a negative effect.³⁶ Most empirical contribution found no effect or small negative one. This paper offers some implications for the interpretation of these empirical results. First, one must bear in mind that exchange rate variability may also be an endogenous response to changes in fundamentals; in this case, such variability may carry an adjustment role and is not necessarily detrimental to trade. Second, under flexible rates, economic uncertainty (whether in fundamentals or in the exchange rate itself) affects unevenly firms belonging to different industries, suggesting that little impact at the aggregate national level may hide large differences in the effects at the industrial level. Third, we have shown that the location incentive tend to make countries more specialized under flexible than under fixed rates; we should then infer that the level of 'inter-industry' trade among given countries should actually be higher under flexible rates (associated with high variability of the exchange rate) than under fixed rates (associated with low or zero variability of the exchange rate). These three considerations show that the theoretical case for a negative effect of exchange rate variability on trade is not so compelling and must be qualified at the industrial level.

This paper presents a clear-cut **implication** for the choice of exchange rate regime and the **optimum currency area** literature. The literature on optimum currency areas stresses that the net-benefits that can be expected to derive from the creation of a currency area depend on several factors,³⁷ and particularly on the degree of symmetry of shocks. On the basis of these factors, such literature suggests that a cost-benefit analysis of the creation of a currency area could be done by looking at the fundamentals and at the structural parameters of the candidate economies.

However, this literature fails to capture that some of these elements may be endogenous to the creation of the currency area itself.³⁸ This paper argues that different exchange rate regimes are associated with different location choices of firms, which in turn

³⁶However, De Grauwe (1988) shows that this negative relation does not always hold in theory.

³⁷Such as the degree of asymmetry of shocks, the rigidities in prices and wages, the international mobility of factors, the availability of fiscal stabilization tools, the degree of openness and diversification of the economies, the different inflationary bias of domestic authorities, and, in the case of a currency union, the deadweight and efficiency gains deriving from the adoption of a single currency. See Ricci (1994) for a two-country model that comprehends most of monetary and real aspects of this analysis, Bayoumi (1994) for an n-country model discussing most of the real aspects. For surveys of the OCA literature, see: Bofinger (1994), De Grauwe (1992), Ishiyama (1975), Krugman (1992), Masson and Taylor (1992), Tavlas (1993, 1994), and Tower and Willet (1976).

³⁸Bayoumi and Eichengreen (1993) and Krugman (1990, 1993) are among the few who note that the correlation of shocks across EU countries may change over time, altering the net benefits we should expect from EMU. The reason they point out is a phenomenon exogenous to the EMU: the creation of a Single Market should make EU countries more specialized. The mechanism we investigate in this paper suggests instead that the change in the correlation of shocks may also be endogenous to the creation of the EMU.

alter the degree of symmetry of shocks across countries. Consequently, considering the importance of the degree of symmetry of shocks in assessing the net-benefits from the creation of a currency area, one should expect that the creation of a currency area affects the fundamentals on which the desirability (as measured by the net-benefits) of the same currency area depends.

More precisely, the net-benefits that can be expected from the creation of a currency area are endogenous to (and rising in) the institution of the currency area, as the latter induces industrial dispersion and consequently reduces the degree of asymmetry of shocks.³⁹ Kenen (1963) argued that more diversified economies are better candidates for a currency area. Our paper argues that there may exist also a reverse relation: the creation of a currency area will make member countries more diversified. This paper therefore extends the optimum currency area literature.

³⁹ Ideally, welfare implications should be drawn by introducing the location effects we identify in this paper into a model tailored to formalize the net benefits of a currency area.

REFERENCES

- Aizenman, Joshua, 1994, "Monetary and Real Shocks, Productive Capacity and Exchange Rate Regimes," *Economica*, Vol. 61.
- , 1992, "Exchange Rate Flexibility, Volatility, and Domestic and Foreign Direct Investment," *IMF Staff Papers*, Vol. 39, No.4 (Washington: International Monetary Fund).
- Bayoumi, Tamim, 1994, "A Formal Model of Optimum Currency Areas," CEPR Discussion Papers No. 968.
- , and Barry Eichengreen, 1993, "Shocking Aspects of European Monetary Integration," in *Adjustment and Growth in the European Monetary Union*, ed. by F. Torres and F. Giavazzi (Cambridge: University Press).
- Blanchard, O.J., and N. Kiyotaki, 1987, "Monopolistic Competition and the Effects of Aggregate Demand," *American Economic Review*, Vol. 77.
- Bofinger, P., 1994, "Is Europe an Optimum Currency Area?" CEPR Discussion Paper, No. 915.
- Broll U., J.E. Wahl, and I. Zilcha, 1995, "Indirect Hedging of Exchange Rate Risk," *Journal of International Money and Finance*, Vol. 14, No. 5.
- , and I. Zilcha, 1992, "Exchange Rate Uncertainty, Futures Markets and the Multinational Firm," *European Economic Review*, No.36.
- Campa, J., and L.S. Goldberg, 1993, "Investment in Manufacturing, Exchange Rates and External Exposure," NBER No. 4378
- Cushman, D.O., 1988, "Exchange Rate Uncertainty and Foreign Direct Investment in the United States," *Weltwirtschaftliches Archiv*, Vol. 124, No. 2.
- De Grauwe, P., 1988, "Exchange Rate Variability and the Slowdown in Growth of International Trade," *IMF Staff Papers*, Vol. 35.
- , 1992, "The Economics of Monetary Integration," New York, Oxford University Press.
- Dell'Ariccia, G., 1996, "Exchange Rate Variability and Trade: Evidence from the European Union" (mimeo, Cambridge, Massachusetts: MIT Press).
- Dixit, A., 1978, "The Balance of Trade in a Model of Temporary Equilibrium with Rationing," *Review of Economic Studies*, Vol. 45.

- Dixit, A., and J.E. Stiglitz, 1977, "Monopolistic Competition and Optimum Product Diversity," *American Economic Review*, Vol. 67.
- Eichengreen, Barry, 1990, "Is Europe an Optimum Currency Area?" NBER Working Papers, No. 3579.
- Elizondo, R.L., and P. Krugman, 1992, "Trade Policies and Third World Metropolis," (mimeo, Cambridge, Massachusetts: MIT Press).
- Frankel, J., and S.J. Wei, 1995, "Regionalization of World Trade and Currencies: Economics and Politics," presented at the NBER pre-conference on "The Regionalization of World Economy" (Cambridge, Massachusetts, July).
- Fischer, S., 1977, "Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule," *Journal of Political Economy*, Vol. 85.
- Gagnon, J.E., 1993, "Exchange Rate Variability and the Level of International Trade," *Journal of International Economics*, Vol. 34.
- Goldberg, L.S., and C.D. Kolstad, 1994, "Foreign Direct Investment, Exchange Rate Variability and Demand Uncertainty," NBER No. 4815.
- Helpman, E., 1996, "The Size of Regions," presented and at the CEPR-CUSO conference on "Trade, Location, and Technology" (Champery, Switzerland, February).
- , and P. Krugman, 1985, *Market Structure and Foreign Trade* (Cambridge, Massachusetts: MIT Press).
- International Monetary Fund, 1984, "Exchange Rate Volatility and World Trade," *Occasional Paper*, No. 28.
- Kenen, P.B., 1969, "The Theory of Optimum Currency Areas: an Eclectic View," in *Monetary Problems of the International Economy*, ed. by R.A. Mundell and A.K. Swoboda (Chicago: University of Chicago Press).
- Krugman, P., 1993, "Lessons of Massachusetts for EMU," in *Adjustment and Growth in the European Monetary Union*, ed. by F. Torres and F. Giavazzi (Cambridge, Massachusetts: Cambridge University Press).
- , 1992, "Second Thoughts on EMU," *Japan and the World Economy*.
- , 1991, "Geography and Trade" (Cambridge, Massachusetts: MIT Press).
- , 1990, "Policy Problems for a Monetary Union," in *The European Monetary System in the 1990s*, ed. by P. De Grauwe and Papademos (Longman, London).

- , 1981, "Intra-Industry Specialization and the Gains from Trade," *Journal of Political Economy*, Vol. 89.
- Krugman, P., and A.J. Venables, 1993, "Integration, Specialization, and Adjustment," CEPR No. 886.
- Masson, Paul R., and M.P. Taylor, 1992, "Common Currency Areas and Currency Unions: A Survey of the Issue," CEPR Discussion Paper No. 617.
- McKinnon, R.I. 1963, "Optimum Currency Areas," *American Economic Review*.
- Martin, P., and G.I.P. Ottaviano, 1996, "Growing Locations: Industry and R&D Location in a Model of Endogenous Growth," presented at the CEPR-CUSO conference on "Trade, Location, and Technology" (Champéry, Switzerland, February).
- , and C.A. Rogers, 1995, "Industrial Location and Public Infrastructure," *Journal of International Economics*.
- Mundell, R.A., 1961, "A Theory of Optimum Currency Area," *American Economic Review*, Vol. 51.
- Neary, J.P., 1980, "Nontraded Goods and the Balance of Trade in a Neo-Keynesian Temporary Equilibrium," *The Quarterly Journal of Economics*.
- Perée, E., and A. Steinherr, 1989, "Exchange Rate Uncertainty and Foreign Trade," *European Economic Review*, Vol. 33.
- Ricci, L.A., 1997, "A Ricardian Model of New Trade and Location Theory" *Journal of Economic Integration*, Vol. 12.
- , 1994, "A Simple Model of an Optimum Currency Area" (mimeo, Harvard University and The Graduate Institute of International Studies). Also in *Institute of Western Europe, Columbia University*, "Proceedings of the 1995 Conference: Europe Toward the 21st Century".
- Tavlas, G.S., 1993, "The New Theory of Optimum Currency Areas," *The World Economy*, Vol. 16, No. 6.
- , 1994, "The Theory of Monetary Integration," *Open Economy Review*, No. 5.
- Trionfetti, F., 1996a, "Public Expenditure and Economic Geography," presented at the CEPR-CUSO conference on "Trade, Location, and Technology" (Champéry, Switzerland, February).

——, 1996b, "Single Market and the Sustainability of Public Debt," presented at the first meeting of the ESF-Funded Research Group on "European Economic Performance" Louvain-la-Neuve, April.

Venables, A.J., 1996 (forthcoming), "Equilibrium Location of Vertically Linked Industries," *International Economic Review*.