NOTES D'ÉTUDES

ET DE RECHERCHE

ACCESS TO NEW IMPORTED VARIETIES AND

TOTAL FACTOR PRODUCTIVITY:

FIRM LEVEL EVIDENCE FROM FRANCE

Delphine Irac

April 2008

NER - E # 204

BANQUE DE FRANCE

EUROSYSTÈME

DIRECTION GÉNÉRALE DES ÉTUDES ET DES RELATIONS INTERNATIONALES

ACCESS TO NEW IMPORTED VARIETIES AND

TOTAL FACTOR PRODUCTIVITY:

FIRM LEVEL EVIDENCE FROM FRANCE

Delphine Irac

April 2008

NER - E # 204

Access to new imported varieties and total factor productivity:

Firm level evidence from France

Delphine Irac[1]

Abstract

This paper aims at providing causal evidence on the effects of expanded imported varieties on total factor productivity (TFP) using French firm level data. Our strategy is to build an exact index of increase in varieties -using the Broda, Greenfield and Weinstein (2006) methodology. This index captures the impact of new varieties on total factor productivity within a Dixit-Stiglitz framework based on a Constant Elasticity of Substitution production function.

We argue that measurement problems are central to the question we try to address. We deal with this issue using alternative instrumental variables strategies. First, we work with sectoral variety index in order to reduce the effect of outliers. Secondly, working with estimated bilateral imports rather than observed ones, we are able to adjust the variety index for measurement errors and find a strong impact of this index on TFP. New varieties that enter the production function appear as weakly substitutable- with an elasticity of substitution ranging from 1.25 and 1.5 - and conducive to significant TFP growth.

Key words: variety, trade, total factor productivity

Résumé

Cet article étudie les effets de l'augmentation du nombre de variétés importées sur la productivité globale des facteurs (PGF) sur données de firmes françaises. Notre stratégie est d'établir un indice de variété en employant la méthodologie mise en œuvre par Broda, Greenfield et Weinstein (2006). Cet indice capture l'impact de nouvelles variétés sur la PGF dans un cadre à la Dixit-Stiglitz basé sur une élasticité de substitution constante. Les estimations directes rapportent des élasticités de substitution très élevées. Les problèmes de mesure sont centraux dans notre analyse. Nous traitons cette question en utilisant des méthodes de variables instrumentales. Premièrement, nous travaillons avec l'indice de variété sectoriel afin de réduire l'effet des valeurs aberrantes. Deuxièmement, en travaillant avec des importations bilatérales estimées plutôt qu'observées, nous sommes en mesure de corriger partiellement l'indice de variété. Nous trouvons un impact fort des indices de variété sur la PGF. Les nouvelles variétés qui entrent dans la fonction de production apparaissent comme faiblement substituables avec pour effet de favoriser de manière significative la croissance de la TFP.

JEL classification: F1, O4

Mots clefs: variétés, commerce international, productivité globale des facteurs

Non technical summary

With the rising integration of world markets, a process of disintegration of the production process through the trade of intermediate inputs has been at work.

This disintegration in the production process goes hand in hand with an increase in varieties, as the seminal model developed by Krugman (1979) shows. It is generally admitted that countries gain from trade through this expansion in the number of traded varieties, what is also referred to as "quality growth" in this paper. However evidence of these gains at the firm level is generally scanty.

This paper aims at providing causal evidence on the effects of expanded imported varieties on firm level total factor productivity (TFP). Our strategy is to build an exact index of increase in varieties -using the Broda, Greenfield and Weinstein (2006) methodology. This index captures the impact of new varieties on total factor productivity within a Dixit-Stiglitz framework based on a Constant Elasticity of Substitution production function. The starting point of this approach consists in a substantial refinement of a simple count of the number of varieties, accounting for the weights of new varieties and their degree of substitution with old ones.

We empirically investigate how *TFP* growth relates to the variety index. With a standard assumption about the share of intermediate inputs in total output, we are able to retrieve an estimate of the elasticity of substitution between goods from different countries. Direct estimations yield very high elasticity of substitution. We argue that measurement problems are central to the question we try to address. Due to potentially frequent misreporting of the origin country in custom declarations, which are not possible to identify through standard datacleaning, the variety index is likely to be crippled with strong measurement errors at the firm level. We deal with this issue using alternative IV strategies. First, we work with sectoral variety index in order to reduce the effect of outliers. Secondly, working with estimated bilateral imports rather than observed ones, we are able to adjust the variety index for measurement errors and find a strong impact of this index on TFP. New varieties that enter the production function appear as very weakly substitutable- with an elasticity of substitution ranging from 1.25 and 1.5 - and conducive to significant TFP growth.

Résumé non technique

En parallèle à l'intégration des marchés mondiaux, un processus de désintégration du processus de production par les échanges de biens intermédiaires est à l'œuvre. Cette désintégration du processus de production va de pair avec une augmentation du nombre de variétés échangées, comme le montre le modèle séminal de Krugman (1979). S'il est généralement admis que les pays tendent à profiter de cette expansion du nombre de variétés, ces gains au niveau de la firme sont peu testés empiriquement.

Cet article étudie les effets de l'augmentation des variétés importées sur la productivité globale des facteurs (PGF) au niveau de la firme. Notre stratégie est d'établir un indice de variété en employant la méthodologie mise en œuvre par Broda, Greenfield et Weinstein (2006). Cet indice capture l'impact de nouvelles variétés sur la PGF dans un cadre à la Dixit-Stiglitz basé sur une élasticité de substitution constante. Le point de départ de cette approche consiste en une amélioration substantielle d'un simple décompte du nombre de variétés, intégrant les poids en valeur de nouvelles variétés et leur degré de substitution avec les variétés anciennes.

Nous étudions empiriquement comment la croissance de la PGF est reliée à cet indice de variété. Avec une hypothèse standard sur la part des entrées intermédiaires dans la production, nous avons ainsi une évaluation de l'élasticité de la substitution entre les variétés. Les estimations directes rapportent des élasticités de substitution très élevées. Les problèmes de mesure sont centraux dans notre analyse. En raison d'erreur de saisies potentiellement fréquentes sur le pays d'origine dans des déclarations de douane et qui ne sont pas identifiables par des méthodes de nettoyage standard, les indices de variété sont susceptibles d'être entachés d'erreurs de mesure fortes. Nous traitons cette question en utilisant des méthodes de variables instrumentales. Premièrement, nous travaillons avec l'indice de variété sectoriel afin de réduire l'effet des valeurs aberrantes. Deuxièmement, en travaillant avec des importations bilatérales estimées plutôt qu'observées, nous sommes en mesure de corriger partiellement l'indice de variété. Nous trouvons un impact fort des indices de variété sur la PGF. Les nouvelles variétés qui entrent dans la fonction de production apparaissent comme très faiblement substituables avec pour effet de favoriser de manière significative la croissance de la TFP.

I. Introduction

In order to explore how trade enhances growth through the creation and import of new varieties, Broda, Greenfield and Weinstein (2006) build an exact index measuring productivity gains due to expanded imported varieties, the so called "lambda ratio", and conduct their analysis using highly disaggregate trade data. However, the model they suggest and the framework they develop relates to mechanisms that are happening at the firm/sector level rather than at the country level. This paper aims at providing causal evidence on the effects of expanded imported varieties on firm level total factor productivity (TFP). It proceeds in four sections. The first section reviews the relevant literature. The second section describes the details of the methodology we follow, and especially the derivation of the lambda ratios. The third section presents the dataset and the variable construction. The fourth section describes the econometric strategy and discusses the results.

II. Related literature

With the rising integration of world markets, a process of disintegration of the production process through the trade of intermediate inputs has been at work (see Feenstra 1998). Among the most famous examples of this "slicing in the value chain" (Krugman 1995) phenomenon, the Barbie dolls or Nike shoes and clothing are most generally mentioned. This disintegration in the production process goes hand in hand with an increase in varieties, as the seminal model developed by Krugman (1979) shows[2]. Though the debate about the significance of the impact of integration on growth and total factor productivity is not empirically settled[3] concerning the price-quantity channel, it is generally admitted that countries gain

---

[2] In Krugman (1979), gains from trade come both from a drop in the equilibrium price (because of the increase in the elasticity of demand) but also from an increase in total product variety. For a textbook presentation, we can refer to Feenstra (1988).

[3] See for instance Rodriguez and Rodrik (2000) vs. Sachs and Warner (1995).

from trade through the expansion in the number of traded varieties, what is also refered to as "quality growth" in this paper. Romer (1994) explores the effects that new goods have on welfare and suggests "to leave behind the confortable vision of a world in which all change comes from increased quantities of existing goods" (what he calls the principle of plenitude that states that the world is full, every conceivable entities already existing). There are basically three ways of conceptualizing the effect of quality growth on price, welfare, growth and productivity. First, according to the hedonic pricing methodology – introduced by Court (1939) and revived by Griliches (1961) – quality growth is seen as an improvement in product characteristics. Goods are viewed as a set of characteristics that have different weights in the consumer utility function. For a very pedagogical presentation of the hedonic price methodology, we can refer to Berndt (1990). Broadly speaking, the most standard approach consists in specifying a functional form (generally semi logarithmic) for the price of a given variety, with the different qualities as arguments. Since this implies exacting data requirements, this method is generally applied to a limited number of goods by statistical institutes[4]. Bils and Klenow (2001) show for instance that the BLS does not fully adjust for quality upgrading, with 60% of the quality growth being captured as higher inflation than higher real growth. A second approach is more concerned with welfare and considers quality growth as the introduction of totally new goods that consumers are unable to purchase until these goods come on the markets. The welfare impact of the introduction of new goods was first studied by Hicks (1942,1946). Hausman (1981, 1997) refines the Hicks approach of a compensated demand curve and calculates a "virtual" or "reservation" price that sets demand for the new good or service to zero. In this approach, the welfare impact of the introduction of new goods is thus estimated as the welfare associated with a price drop from the

---

[4] For instance, we can refer to Shapiro and Wilcox (1996) concerning the BLS price statistics and also to the Boskin Commission Report.

relatively high reservation price to the lower current price. This review of literature being by no means exhaustive, numerous references can be found in Petrin (2002).

A third approach focuses on the effect of quality growth on growth, consumer price index and total factor productivity. Broadly speaking, its starting point consists in a refinement of a simple count of the number of varieties, accounting for the weights of new varieties and their degree of substitution with old ones. In international trade, globalization, as we saw, does not only affect price and quantity but also the number of traded varieties which official international statistics do not totally take into account but having potentially strong implications in terms of productivity and welfare. For instance, the assumption that the set of goods never changes tends to significantly underestimate the welfare loss of protection (see Feenstra 1992, Romer 1994, Klenow and Rodriguez-Clare[5] 1997, Rutherford and Tarr 2002). Funke and Ruhwedel (2001) utilizing data for 19 OECD countries, find support that a higher degree of product variety relative to the US helps to explain relative per capita GDP levels. Their empirical work relies upon some direct measures of product variety calculated from 6 digit OECD export and import data. However, the model they base their study upon which draws heavily on Feenstra (1994), does not include elasticities of substitution among varieties. However, if there is a lot of substitution across varieties then GDP per capita has little chance to be impacted by an increase in the number of varieties. Using a significantly more disaggregate and exact methodology than Funke and Ruhwedel (2001), Broda and Weinstein (2004) "document some stylized facts about the growth in global varieties which suggest that there may have been substantial welfare gains through the import of new varieties". They show that the "average large importing countries source imports from 50 percent more countries than they did 25 years ago". Moreover, they calculate the impact of increased variety on import prices and find that

---

[5] They find that trade liberalization that occured in Costa Rica between 1986 and 1992 was accompanied by a surge in import variety.

conventional measures of import price inflation may be biased upwards. Concentrating on the US economy, Broda and Weinstein (2006) "reconstruct the US import price index and show that the unmeasured growth in product variety from US imports has been an important source of gains from trade over the last three decades (1972-2001)". They use Feenstra's (1994) methodology to "estimate 30,000 elasticities and then construct an aggregate price index that is robust to common changes in quality variation, the arbitrary splitting of categories, the introduction of new goods". They document that "the number of varieties imported by the US, defined as the number of import categories multiplied by the average number of source countries for each category, quadrupled". About half of this increase was due to increases in the number of categories and half due to a doubling of the number of countries from which the US imported each good. They find that the price of US imports has been falling at "a rate 1.2% per year faster than one would have thought without taking new varieties into account". In a more recent paper, shifting their focus from import prices to TFP, Broda, Greenfield and Weinstein (2006) "using highly disaggregated trade data structurally estimate the impact that new imports have had on productivity in approximately 4000 markets per country". They build "an exact TFP index that aggregates these micro gains and find that the typical country in the world experienced a net increase in varieties of 0.7 percent per year", with France experiencing an increase of almost 1% per year[6], which is much higher than the median developed country (contribution of 0.4 percent).

III. Methodology

To quantify the potential gains in total factor productivity from input variety, we chose a Spence-Dixit-Stiglitz framework with a constant elasticity of substitution (CES) production function. The concept of monopolistic competition is relatively old

---

[6]   cf table 4 of their paper.

since its grounds were laid out by Chamberlain (1933). Four hypotheses can describe the monopolistic competition model. First, firms sell products of the same type but imperfectly substitutable (concept of variety). Second, each firm produces a single variety with increasing returns and set its price. Third, the number of firms in the industry is high enough in order to ensure that each firm is negligible relatively to the others. Fourth, the free entry condition in the industry guarantees zero profit. Therefore each firm is in a monopolistic situation in her own market (where the variety she produces is sold) but given that other firms exist which produce other varieties the size of this market depends on the behaviour of other firms and some restrictions are imposed as to how freely the producer can set its price. The reason why the number of varieties does not grow to infinity in this model exhibiting increasing returns is because fixed costs are associated to new varieties. Spence (1976) and Dixit-Stiglitz (1977) propose a way of modelling Chamberlain's ideas that could be used in different fields of economics. Krugman (1979, 1981) develops an extension to international economics of this Spence-Dixit-Stiglitz formalization of the chamberlinian monopolistic competition. The model provides an explanation to the large volume of exchange of manufactures between the industrialized economies, which the Heckscher-Ohlin-Samuelson trade model fails to explain[7]. In this paper, our interest is not about differentiated consumer goods but differentiated producer goods, in line with Ethier (1982)[8] model, for which Helpman and Krugman (1985, part 3, chapter 11) provides a generalization assuming a general cost function depending on all factor prices plus the number of

---

[7] As Hummels and Klenow (2002) underline, "big countries trade larger quantities of goods (intensive margin) but also a larger set of goods (extensive margin)". For instance, using data on shipments by 110 exporters to 59 importers in 5,000 product categories they find that the extensive margin "accounts for two-thirds of the greater exports of larger economies, and one-third of the greater imports of larger economies". This result might appear as standing in conflict with the prediction of Krugman's monopolistic competition model, whereby economies increase exports only through the extensive margin channel. Alternatively, in Armington (1969) model, expansion takes place through higher quantity of each variety sold at lower price (intensive margin).

[8] In Ethier (1982), no capital and labour are used in the production function.

varieties. More recently, this type of production function has been tested in Harrigan (1995).

General intuition: number of goods in a CES function

The interaction between product variety and economic growth can be simply illustrated by a model where a country produces a homogenous output good, *Y*, using labor, *L*, capital, *K*, and a range of differentiated intermediate goods, M_g. A Cobb-Douglas function describes the production of Y $Y_t = \overline{A} L_t^{1-\alpha-\beta} K_t^{\beta} M_t^{\alpha}$ with $\overline{A}$ being the rate of technological progress and M being given by the aggregation of goods M_g through a standard CES function, with elasticity of substitution γ.

$$M_t = \left(\sum_{g \in G} M_{gt}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} \text{ and } G = \{1,...,n\}$$

The total number of differentiated inputs add up to what we define as total intermediate consumption, *C*: $C_t = \sum_{g \in G} M_{gt}$

Treating intermediate inputs symmetrically in the production function, we have:

$$M_{gt} = \frac{C_t}{n} \text{ for any g}$$

It is straightforward to check: $M_t = n^{\frac{1}{\gamma-1}} C_t$

Be rewriting this expression as $M_t = n^{\frac{1}{\gamma-1}} n(C_t/n)$, we see that for a constant C_t/n an increase in the number of varieties *n* leads to an increase in M_t that is greater than *n* time C_t/n. Therefore this production function exhibits increasing returns to scale that directly come from a greater division of labor, what Ethier (1982) refers to as "international returns to scale". Another way to look at this property of the CES production function is to see that the number of intermediate goods, *n,* enters the production function. Hence building a TFP index, $\widetilde{A}$, as a simple Solow Residual

without taking variety into account will lead to assimilate the rate of technological

progress, $\overline{A}$, with variety, n, increase.

$$\widetilde{A} = \frac{Y_t}{L_t^{1-\alpha-\beta}K_t^{\beta}C_t^{\alpha}} = \overline{A}\,n^{\frac{\alpha}{\gamma-1}}$$

n has a direct impact on total factor productivity, as measured by $\widetilde{A}$. For a given

total amount of aggregate intermediate inputs, C, the higher the number of varieties

that enter C, the higher $\widetilde{A}$.

Theoretical model

We start with the model described in the first paragraph of this section but add one

more tier to the production process, in line with Broda and Weinstein (2004, 2006)

and Broda, Greenfield and Weinstein (2006). The production function is Cobb-

Douglas as described above with the first tier positing that M_t comes from the

aggregation of goods g at time t.

$$M_t = \left(\sum_{g \in G} M_{gt}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}$$

Where γ is the elasticity of substitution across goods. Each good g comes from

aggregating a set I_{gt} of varieties m_{git} (i denoting the variety), purchased at price p_{git}.

$$M_{gt} = \left(\sum_{i \in I_{gt}} d_{git}^{\frac{1}{\sigma_g}} \left(m_{git} \right)^{\frac{\sigma_g-1}{\sigma_g}} \right)^{\frac{\sigma_g}{\sigma_g-1}}$$

Where σ_g is the elasticity of substitution across varieties and d_{git} is a technological

parameter. We will discuss what g and i exactly represent in a following section. For

11

each good g, it is straightforward to derive the expression for the minimum cost associated with purchasing one unit of intermediate good *g:*

$$\begin{cases} Min \sum_{i \in I_{gt}} p_{git} m_{git} \\ s.t. M_{gt} = 1 \end{cases}$$

Solving the optimization problem yields the unit-costs function :

$$c\left(p_{gt}, I_{gt}, d_{gt}\right) = \left(\sum_{i \in I_{gt}} b_{git} p_{git}^{1-\sigma_g}\right)^{\frac{1}{1-\sigma_g}}$$ with b_{git} being expressed in function of d_{git} and p_{gt}

being the vector of variety prices.

Differentiating the unit-cost function, we get the expenditure shares s_{git}.

$$s_{git} = \frac{p_{git} m_{git}}{\sum_{i \in I_{gt}} p_{git} m_{git}} = \frac{\partial \ln c\left(p_{gt}, I_{gt}, d_{gt}\right)}{\partial \ln p_{git}} = c\left(p_{gt}, I_{gt}, d_{gt}\right)^{\sigma_g - 1} b_{git} p_{git}^{1-\sigma_g}$$

Hence, taking the ratio between two time periods, s and t (s<t):

$$\frac{c\left(p_{gt}, I_{gt}, d_{gt}\right)}{c\left(p_{gs}, I_{gs}, d_{gs}\right)} = \frac{p_{git} s_{gis}^{1/(1-\sigma_g)}}{p_{gis} s_{git}^{1/(1-\sigma_g)}}$$ for any variety i.

This leads us to the following definitions and properties:

Definition 1: We define the Sato-Vartia log-ideal weight w_{gits} between time t and time s of each variety *i* in good *g* as[9]: $$w_{gits} = \frac{\dfrac{s_{git} - s_{gis}}{\ln s_{git} - \ln s_{gis}}}{\sum_{i=1}^{N} \dfrac{s_{git} - s_{gis}}{\ln s_{git} - \ln s_{gis}}}.$$

Definition 2: The Sato-Vartia price index relative to good *g* between period *t* and period *s* is given by:

$$\Sigma_{gts} = \prod_{i \in I_g} \left(\frac{p_{git}}{p_{gis}}\right)^{w_{gits}}$$

---

[9] It can be shown that this weight is approximately equal to: 1/3 arithmetic mean+ 2/3 geometric mean between s_{git} and s_{gis}.

With I_g, being the set of varieties that are common in t and s ($I_g = I_{gt} \cap I_{gs}$).

Definition 3: A price index is "exact" (Diewert) if this price index equals the ratio of unit-costs.

Property 1: Under the assumption of constant I_{gt} (and constant b_t), the Sato-Vartia price index Σ_{gts} is exact: $\Sigma_{gts} = \dfrac{c(p_{gt}, I_{gt}, d_{gt})}{c(p_{gs}, I_{gs}, d_{gs})}$

Property 2: Under the assumption that I_{gt} is non constant:

$$\Sigma_{gts} = \frac{c(p_{gt}, I_{gt}, d_{gt})}{c(p_{gs}, I_{gs}, d_{gs})} (\lambda_{tg}/\lambda_{sg})^{1/(\sigma_g - 1)} \text{ with } \lambda_{tg} = \frac{\sum\limits_{i \in I_g} p_{git} m_{git}}{\sum\limits_{i \in I_{gt}} p_{git} m_{git}}$$

Definition 4: The Sato-Vartia price index relative to the composite good between period t and period s is given by:

$$\Sigma_{ts} = \prod_g \Sigma_{gts}^{w_{gts}}$$

If the set of varieties in t and s was the same and the taste parameters d time unvarying, we hence know that the Sato-Vartia price index would be "exact" (Diewert), i.e. equal to the ratio of unit-costs in t and s. However a bias between the Sato-Vartia price index and the ratio of unit-costs arises from the fact that the set of varieties in t and s, I_{gt} and I_{gs}, are not identical. The aggregation of goods g to get the composite good M_t, will lead to a bias in the resulting price index equals to:

$$\prod_g (\lambda_{tg}/\lambda_{sg})^{w_{gts}/(\sigma_g - 1)}$$

With w_{gt} being the Sato-Vartia log-ideal weight of good g in total composite intermediate good[10].

Property 3: $\prod_{g}\left(\lambda_{tg}/\lambda_{sg}\right)^{w_{gts}/(\sigma_g-1)}$ gives the bias in estimating change in the unit costs associated with intermediate consumption by price indices that are based on common varieties only. By the same token, $\prod_{g}\left(\lambda_{tg}/\lambda_{sg}\right)^{\alpha w_{gts}/(\sigma_g-1)}$ gives the bias in estimating total factor productivity.

Let us expand the expression for this bias in TFP estimation and detail how it is determined:

$$\prod_{g}\left(\lambda_{tg}/\lambda_{sg}\right)^{\alpha w_{gts}/(\sigma_g-1)} = \prod_{g}\left(\frac{\sum_{i\in I_g} p_{git}m_{git}}{\sum_{i\in I_{gt}} p_{git}m_{git}} \cdot \frac{\sum_{i\in I_{gs}} p_{gis}m_{gis}}{\sum_{i\in I_g} p_{gis}m_{gis}}\right)^{\alpha w_{gts}/(\sigma_g-1)}$$

First we observe evidently that if the set of varieties is constant for each good, this bias boils down to 1. If I_g is small compared to I_{gt}, lots of new i's appeared between time s and time t, varieties creation was strong and λ_{tg} is low and so is the lambda ratio. However, if new i's that appeared between s and t account for a small proportion of good g; the downward impact of these new varieties on the lambda ratio will not be so big. Symmetrically, if many i's were in I_{gs} but not in I_g, it means that the process of variety destruction was strong. λ_{sg} will be high, driving up the lambda ratio and moderating the effect of variety creation reflected by a low λ_{tg}. Hence the lambda ratio can be interpreted as a measure of net increase in varieties. The lower is the lambda ratio, the more intense variety creation. The effect of variety

---

10 $w_{gts} = \dfrac{\dfrac{s_{igt}-s_{igs}}{\ln(s_{igt})-\ln(s_{igs})}}{\displaystyle\sum_{g\in G}\dfrac{s_{igt}-s_{igs}}{\ln(s_{igt})-\ln(s_{igs})}}$

creation on the lambda ratio will be high only to the extent that new varieties account for a large proportion of the intermediate good. The lambda ratios are calculated at the level of each good *g.* The aggregation of these good-level biases gives the total bias related to the composite intermediate good. We obtain the impact on TFP by raising this expression to the power[11] α , which reflects the weight of intermediate consumption in total output. The weight of each good in the aggregate bias will naturally increase with its Sato-Vartia log-ideal weight together with the elasticity of substitution of the good. Indeed, clearly, if a good exhibits new varieties but is highly substitutable, the impact of these new varieties on the composite intermediate good will not be so large.

IV. Dataset and variable construction

We work on a database including information on French importing firms and resulting from the matching of two databases. The first database comes from custom declarations. It contains the amount of importations of all importing firms (identified with an identification code "SIREN") for each year between 1993 and 2003, for each product at a 4 digit level classification and by origins of imports. This file is similar to the one used in Biscourp and Kramarz (2007) but they work on the period 1986-1992. We match this custom database with a subpart of the "FIBEN" database (Banque de France balance sheet dataset). Clerks in the different local subsidiaries of the Bank de France contact firm to complete a survey. The Fiben database comes from the collection and the cleaning of these surveys, including all businesses with more than 50 employees and a fraction of smaller firms. Its coverage ratio (in terms of number of employees) is 57% but is smaller for service sectors. The Banque de France uses these data (plus information from banks including payment incidents) for computing the firm score, which is

---

[11] The exponent a represents the share of intermediate consumption in total output.

massively used by commercial banks for evaluating the financial risk for each firm (see Bardos 1998). The database includes the different variables of a standard firm tax forms plus a set of complementary variables. In particular we have information about total wage bill, number of employees, intermediate consumption for each year and each firm.

Construction of increase in varieties

Whereas it is straightforward to think that two products within a narrow category correspond to two varieties of the same good, assuming that different countries export different varieties is somewhat less natural. Several papers provide support for that assumption. Schott (2001) shows that for a given variety, the richer the origin country, the higher the export price to the US. Davis and Weinstein (2002) stress the "striking difference in the number of suppliers of particular product categories and give as the most obvious explanation that importers will tend to source differentiated goods from a wide number of countries". Their argumentation is based on a the idea that the "sourcing of homogeneous goods can be modelled by a linear programming problem (Dorfman, Samuelson, and Solow 1958) which gives only a very small number of non zero paths". Therefore a high number of suppliers of a good is an indication that the good is highly differentiated.

This paper defines a variety as an origin country[12]. We assume that firms import as many varieties as we observe origin countries in their custom declarations. This alternative definition may appear as strongly limitative but we need this assumption to treat goods that are produced in France and goods that are produced abroad

---

[12]   An alternative option would be to limit ourselves to imports and view variety as the combination of a 4 digit product and an origin country. This option would be the closest to the way Broda, Greenfield and Weinstein define a variety. For each firm we have the breakdown of her imports at the 4 digit level together with the origin country of imports. We reproduce tables 1 to 3 using this option and show that the results are robust to this alternative hypothesis.

symmetrically in the CES production function. Indeed we do not have a breakdown of domestically produced intermediate consumptions by types of goods.

One way to look at the increase in the number of varieties would be to do a simple count for each firm and each good. As we saw in a previous section, in a simple framework assuming symmetry across varieties, the number of varieties n can determine *TFP*, the source of which is left unidentified by the simple neoclassical growth model. However, two problems arise from using *n* as a direct measure of varieties. As Broda and Weinstein (2006) explain, first, "if new varieties represent only a small (large) share of total expenditure in a good, then a simple count of varieties will grossly overestimate (underestimate) the true impact of new varieties". Secondly, if new varieties are arbitrarily introduced due to some "administrative" changes in the statistical classification, then a simple count artificially increases biasing the increase in product variety upwards. We hence use lambda ratio index since they are meant to give us an exact measure of the impact of variety increase on TFP.

In the one sector case (increase in varieties stems only from increase in origin countries), this lambda ratio index is calculated as:

$$\frac{\lambda_{tj}}{\lambda_{t-1j}} = \frac{\sum_{c\in I_{tj}\cap I_{t-1j}} p_{cjt} m_{cjt}}{\sum_{c\in I_{tj}} p_{cjt} m_{cjt}} \frac{\sum_{c\in I_{t-1j}} p_{cjt-1} m_{cjt-1}}{\sum_{c\in I_{tj}\cap I_{t-1j}} p_{cjt-1} m_{cjt-1}}$$

Where I_{tj} represents the set of countries c firm j imports from at time t.

Similarly, increase in varieties can be computed in the same way at the sector level, replacing firms j with sectors in the above given formula. According to this measure, a variety will be considered as a new variety if it is purchased at time t by at least one firm in the sector but was not imported at time t-1 at all. A variety that disappears is counted exactly in the opposite way.

Total Factor Productivity computation

As the theoretical model developed in the third section makes it clear, increase in varieties is likely to have an impact on TFP only to the extent that we work with output TFP (what we called $\tilde{A}$). Value-added TFP only captures the efficiency of the combination between capital and labour and not the gains coming from a finer division in intermediate inputs. One major problem we faced in computing output TFP is the calculation of real capital stock, since FIBEN includes balance sheet data only. To be more specific, working on balance sheet data, the value of physical assets that is reported in FIBEN is given at historical costs. For instance, suppose that the 1993 capital stock of firm *i* was entirely purchased in 1970 by firm *i*, the value of this capital stock that appears in firm *i*'s balance sheet is the amount in 1970 euros that firm *i* paid for it in 1970. Thus we would need to deflate by 1970 price level to infer the corresponding volume of capital stock. Therefore we need to estimate the average age of capital, which we do not directly observe, to adjust for this price effect and construct accurate measure of capital stocks in volume.

Using two alternative methods, we estimate two different measures of capital stocks in volume that account for differences in the average age of capital (see appendix). Once we have estimated capital stocks, TFP for firm *j* at time *t* is computed as a Solow Residual:

$$TFP_{j,t} = \frac{Y_{j,t}}{K_{j,t}^{\beta_j} L_{j,t}^{1-\alpha_j-\beta_j} C_{j,t}^{\alpha_j}}$$

1-β_j-α_j and α_j are taken respectively as the shares of intermediate consumption and of wage bill in total production. The parameter for capital stock, β_j, is computed as a residual. These parameters are calculated as a time average of the firm level

relevant ratios assuming that the production function varies across firms but is constant over time.

V. Econometric strategy and results

We want to empirically investigate how *TFP* growth of firm j between time *s* and time *t* relates to the increase in varieties that are imported by firm j between these two periods. The baseline equation is the following:

$$\ln(TFP_{t,j}) - \ln(TFP_{s,j}) = \theta \text{lambda ratio}_{t,s,j} + c + \varepsilon_{t,s,i}$$

As we saw in section 3, θ can be theoretically identified as $\alpha/(\sigma_g - 1)$. α being the share of intermediate consumption in total output (generally estimated around[13] 0.5 for France), an estimate of θ consequently provides an estimate of σ_g. We opt for a geographical way of defining varieties: one variety is associated with one origin country. The TFP measure we use is based on the permanent inventory method but we check the robustness of all results by running the regressions using the alternative capital stock. Appendix provides general summary statistics about the dataset. Firms in our dataset belong to the following sectors: manufacture of food products, beverages and tobacco, manufacture of consumer goods, manufacture of motor vehicles, manufacture of capital goods, manufacture of intermediate goods, energy, construction, retail, transports, services to businesses. We can see that the average number of origin countries per firm increases from 3.8 to 4.1 between 1994 and 1998 to decline to 3.4 in 2001, as if the peak of globalization process had taken place after the launch of the European Union. According to these figures, a

---

[13] See for instance:
  http://www.insee.fr/fr/indicateur/cnat_annu/base_2000/documentation/methodologie/resume_nb1
  .htm

globalization process was strongly at work in the 1990s and seems to have been declining or at least decelerating after 1998. Appendix shows descriptive statistics for the BGW index of increase in varieties. On average, the contribution of import varieties to productivity is 0.01 which is lower than Broda, Greenfield and Weinstein estimate for France (0.09). Two reasons can explain this difference. First, we have firms from the service sector in our dataset whereas Broda, Greenfield and Weinstein focus on the manufacturing sector only. Second, we rely on a more restrictive definition of variety (origin country only) whereas product differenciation (6 digit) is taken into account in their paper. In order to make sure that results do not depend on outliers, we perform the following data cleaning. In the raw version of our dataset, certain firms have increase in varieties by more than 500%, which we do not consider as realistic values. We chose to exclude firms having a lambda ratio above 3 and below 0.33%. TFP growth ranges from -250% to 210% and we do not perform any data cleaning with respect to this variable. This data cleaning entails the exclusion of about one third of the observations. The discarded observations are evenly distributed across sectors. This datacleaning may appear as massive compared to usual ones discarding the 5% tails but given the huge skewness of the distribution, we wanted to make sure that our results do not hinge on a few outliers. We are left with 117882 observations covering 28586 firms. Working at the sector level, we can compute the variety creation/destruction of the whole sector and the maximum and minimum values are ranging from -80% to 60%. At the sector level, it is worth noting that the mean contribution of varieties evolves in line with the average number of origin countries per firm. Table 1 gives the estimation results from regressing firm level TFP growth on firm contribution of variety. The first column gives the estimation output by ordinary least square (OLS), the second by fixed effects estimation and the third one by random effects estimation. The impact of import varieties on TFP growth is not significant and the elasticity of *TFP*

to the index of variety increase is estimated at 0.003, implying $\sigma_g \approx 200$. According to this estimation, the elasticity of substitution across varieties is so high that the impact of new varieties on *TFP* is almost zero.

Table 1. Firm level regression

Endogenous variable	TFP growth		
Estimation method	OLS	FE	RE
Impact of varieties	0.003	0.002	0.003
	(1.39)	(0.76)	(1.27)
Constant	yes	yes	yes
R2	0.00	0.00	0.00
Observations	177882	177882	177882
Number of firms		28586	28586

Robust t statistics in parentheses
*significant at 10%; ** significant at 5%; *** significant at 1%*
The Hansen tests show that the RE estimator is consistent

However, two econometric issues arise from this empirical strategy. First, the lambda ratios are calculated at the firm level, with potentially strong measurement errors for some firms. Any single misreporting of an origin country can potentially yield considerable error measurement in the lambda ratio for a given firm. As textbooks show, the OLS estimator is biased and inconsistent in case of error of measurement of the regressors (downward bias). Secondly, at the firm level, the increase in variety growth might be thought as not totally exogenous with respect to *TFP* growth (upward bias). For instance, due to the fixed costs of imports, in a given sector, firms facing big positive TFP shocks might be able to increase the number of imported varieties in a large proportion. Hence, a positive TFP shock may entail an increase in the number of imported varieties. Also, positive demand shocks make firms more profitable and hence increase the number of countries they outsource from. The instrumental variable (IV) estimator can be a potential solution to these two econometric problems (measurement error and endogeneity). We first use the sectoral increase in varieties as an instrument for firm level product varieties. We define a sector at the 3 digit level (NAF 700, 550 categories). The median sector includes 20 firms and 140 observations (mattress fabrication, computers...).

Though 25% of sectors have more than 56 firms (386 observations), 25% have less than 6 firms. Therefore we keep in mind that this sectoral instrument might not be totally exogenous given the low number of firms in certain sectors. We build lambda ratios using sectors as the level of analysis to measure variety creation and destruction. This measure is less dependent on outliers. Table 2 gives the results of the IV regressions. We see that the coefficient on variety is higher (around 1.2 for the FE estimation)[14]. However, the significance is low when controlling for intragroup correlation at the sector level. Table 3 shows the results including sales as a control variable, the coefficient is estimated between 1.0 and 1.2 which is coherent with the previous estimations (no control variables). The underlying elasticity of substitution is around[15] 1.25.

Table 2: IV regressions using sectoral increase in variety (broad definition)

Endogenous variable	TFP growth				
Estimation method	IV	IV FE	IV RE	IV[++]	IV FE[++]
Impact of varieties	1.826	1.226	1.826	1.826	1.226
	(2.04)*	(1.94)	(2.04)*	(1.21)	(1.35)
Hansen J statistics	0.00	0.00	0.00	0.00	0.00
Anderson LR test	6.70	6.70	6.70	6.70	6.70
(P stat in brackets)	(0.0096)	(0.0096)	(0.0096)	(0.0096)	(0.0096)
Observations	177862	175348	177862	177862	175348
Number of firms		26070	28584		26070

Robust t statistics in parentheses
*significant at 10%; ** significant at 5%; *** significant at 1%*
[++]adjust standard errors for intragroup correlation (sector clustering) for the IV and IV FE
Instruments: Instruments: increase in the number of varieties, BGW index, measured at the sector level

---

[14] Using the alternative definition of varieties (a variety defined as the combination of an origin country and a 4 digit product) yields similar results for tables 1 to 3.

[15] Using the formula: $\sigma_g = 0.5 / \hat{\theta} + 1$

Table 3. IV regressions using the sectoral growth of variety

Endogenous variable	TFP growth				
Estimation method	IV	IV FE	IV RE	IV [++]	IV FE[++]
Impact of varieties	1.236	0.979	1.236	1.236	0.979
	(1.73)	(1.69)	(1.73)	(1.06)	(1.23)
Sales (growth) sector	0.183	0.201	0.183	0.183	0.201
	(18.77)**	(19.14)**	(18.77)**	(11.11)**	(13.68)**
Hansen J statistics	0.000	0.000	0.000	0.000	0.000
Anderson LR test	6335	6335	6335	6335	6335
(P value in brackets)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Observations	177836	175322	177836	177836	175322
Number of firms		26070	28584		26070

Robust t statistics in parentheses
*significant at 10%; ** significant at 5%; *** significant at 1%*
[++]adjust standard errors for intragroup correlation (sector clustering) for the IV and IV FE
Instruments: increase in the number of varieties, measured at the sectoral level

We now want to build a measure of variety growth that is not driven by sector specific demand shocks. To do so, we isolate the part of sectoral imports that is only driven by exchange rates variation. This measure will depend only on international macro-economic development and can therefore be assumed as exogenous to sectoral TFP growth. We build a predicted lambda ratio index that we define as follows:

$$\frac{\hat{\lambda}_{tk}}{\hat{\lambda}_{t-1k}} = \frac{\sum\limits_{c \in I_{tk} \cap I_{t-1k}} \hat{V}_{ckt}}{\sum\limits_{c \in I_{tk}} \hat{V}_{ckt}} \frac{\sum\limits_{c \in I_{t-1k}} \hat{V}_{ckt-1}}{\sum\limits_{c \in I_{tk} \cap I_{t-1k}} \hat{V}_{ckt-1}} \text{ for each sector k}$$

With $\hat{V}_{ckt}$ being defined by the following procedure. Let V_{cjt} represents the value of imports of firm j from country c in period t: $V_{cjt} = p_{cjt} m_{cjt}$. We run the following Tobit regression :

$$V_{cjt} = V_{cjt}^* \text{ if } V_{cjt}^* > 0$$

$$V_{cjt} = 0 \text{ if } V_{cjt}^* \leq 0$$

where V_{cjt}^* is a latent variable : $V_{cjt}^* = \omega XR_{ct} + \tau + \varepsilon_{cjt}$

XR_{ct} represents the real exchange rate of country c. We run regressions for around 500 sectors and 100 countries and therefore run around 50,000 regressions. ω and

τ are estimated for each sector and each country. Appendix gives examples of these regressions for some major countries. For around 2/3 of the occurrences, $\hat{\omega}$ appears as significantly different from 0, with a positive sign. In the remaining cases, the coefficient is not significantly different from 0 or has the wrong sign (in less than 5% of the estimations). From this exercise, we deduce $\hat{V}_{ckt}$, Tobit predicted value, capturing the part of sectoral imports which is driven by exchange rates only:

$$\begin{cases} \hat{V}_{ckt} = \hat{\omega}_{kc}XR_{ct} + \hat{\tau}_{kc} \text{ if } \hat{\omega}_{kc}XR_{ct} + \hat{\tau}_{kc} > 0 \\ \hat{V}_{ckt} = 0 \text{ if } \hat{\omega}_{kc}XR_{ct} + \hat{\tau}_{kc} \leq 0 \end{cases}$$

From this, we build predicted sectoral lambda ratios that we use as an instrument in the regression of TFP on increase in variety. The correlation between the predicted lambda ratio and the observed one is around 0.4. Tables 4 and 5 give the estimation output of the IV regressions using the predicted lambda ratios. The estimated coefficients range between 1.22 and 1.36 (with fixed effect and random effect estimations). The underlying elasticity of substitution, σ_g, is around[16] 1.5, which may appear as relatively low, compared to the elasticities reported in Broda, Greenfield and Weinstein (2006) for France[17]. However their elasticities refer to substitution across 6-digit Harmonized System product category from a particular country, whereas we are concerned with substitution across all the goods from a particular country, which is likely to be way lower. New varieties that are used as intermediate inputs appear as weakly substitutable and are therefore conducive to higher TFP growth. The correlation does not seem to hinge upon reverse causality effects or endogeneity issue.

---

[16] Using the formula: $\sigma_g = 0.5 / \hat{\theta} + 1$

[17] The 3-digit elasticity they report is 3.71 for the median product, ranging from 1.06 to 131 with a mean of 6.03.

Table 4. IV regressions using the predicted lambda ratios as instrument. No control variable

Endogenous variable	TFP growth				
Estimation method	IV	IV FE	IV RE	IV [++]	IV FE[++]
Impact of varieties	1.962	1.350	1.359	1.962	1.350
	(3.34)**	(3.29)**	(3.58)**	(2.22)*	(2.45)*
Hansen J statistics	0.000	0.000	0.000	0.000	0.000
Anderson LR test	5.649	5.649	5.649	5.649	5.649
(P stat in brackets)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Observations	177853	175339	177853	177853	175339
Number of firms		26067	28581		26067

Robust t statistics in parentheses
*significant at 10%; ** significant at 5%; *** significant at 1%*
[++]adjust standard errors for intragroup correlation (sector clustering) for the IV and IV FE
Instruments: increase in the number of varieties, measured at the sectoral level

Table 5. IV regressions using the predicted lambda ratios as instrument controlling for sectoral sales

Endogenous variable	TFP growth				
Estimation method	IV	IV FE	IV RE	IV [++]	IV FE[++]
Impact of varieties	1.645	1.223	1.244	1.645	1.223
	(3.13)**	(3.12)**	(3.37)**	(2.17)*	(2.48)*
Sales (growth) sector	0.178	0.197	0.195	0.178	0.197
	(20.41)**	(22.11)**	(23.82)**	(13.51)**	(16.97)**
Hansen J statistics	0.000	0.000	0.000	0.000	0.000
Anderson LR test	5.245	5.245	5.245	5.245	5.245
(P stat in brackets)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Observations	177827	175313	177827	177827	175313
Number of firms		26067	28581		26067

Robust t statistics in parentheses
*significant at 10%; ** significant at 5%; *** significant at 1%*
[++]adjust standard errors for intragroup correlation (sector clustering) for the IV and IV FE
Instruments: increase in the number of varieties, measured at the sectoral level

Concluding remarks

The purpose of this paper is to investigate international returns to scale, stemming from the disintegration of the production. Our strategy is to build an exact index of increase in varieties (the lambda ratio index) that is supposed to reflect the impact of new varieties on TFP within a Spence-Dixit-Stiglitz framework with a CES production function. The standpoint we chose is purely econometrical since we are concerned about the correlation coefficient between the lambda ratio index and growth in TFP at the firm level. With a standard assumption about the share of intermediate inputs in total output, we are able to retrieve an estimate of the

elasticity of substitution between goods from different countries. An alternative standpoint could have been accounting: using existing estimates of the elasticities of substitution - for instance the ones provided by Broda, Greenfield and Weinstein (2006) - we could have investigated how much TFP growth is attributable to variety expansion. Measurement problems are central to the question we try to address. Due to potentially frequent misreporting of the origin country in custom declarations, that are not possible to identify through standard datacleaning, the lambda ratios are likely to be crippled with strong measurement errors at the firm level. A great deal of our endeavour in this paper is precisely to deal with this issue. Especially, working with estimated bilateral imports rather than observed ones, we are able to adjust the lambda ratios index for measurement errors and find a strong impact of the lambda ratio on TFP. New varieties that enter the production function appear as weakly substitutable - with an elasticity of substitution ranging from 1.25 and 1.5 - and conducive to significant TFP growth.

References

Armington, P.S. (1969), "A theory of demand for products distinguished by place of Production", International Monetary Fund Staff Papers, vol. 16, pp. 159–76.

Bardos (1998), "Detecting the risk of company failure at the Banque de France", *Journal of Banking and Finance*, 1998, vol. 22, issue 10-11, pp. 1405-1419.

Berndt, E. R. (1990), "The measurement of quality change: constructing an hedonic price index for computers using multiple regression methods." In: Berndt, E. R. *The practice of econometrics: classic and contemporary.* Reading, MA, Addison-Wesley, 1990.

A. Bils and P. Klenow (2001), "Quantifying Quality Growth", *American Economic Review*, September 2001.

Biscourp P. and F. Kramarz (2007), «Employment, Skill Structure, and International Trade », *Journal of International Economics*, 72, May, 22-51.

Broda C., J. Greenfield and D. Weinstein (2006), "From Groundnuts to Globalization: A structural estimate of Trade and Growth", No 12512, NBER Working Papers.

Broda C.and D. Weinstein (2004), "Variety Growth and World Welfare", *American Economic Review Papers and Proceedings*, XCIV (2004), pp. 139-145.

Broda C and D. Weinstein (2006), "Globalization and the Gains from variety", *Quarterly Journal of Economics*, MIT Press, vol. 121(2), pp. 541-585, May.

Boskin Commission Report. 1996. "Toward a more accurate measure of the cost of living, Final report to the Senate Finance Committee from the Advisory Commission to study the Consumer Price Index." (Available at http://www.ssa.gov/history/reports/boskinrpt.html.)

Chamberlin E. *(1933), Theory of Monopolistic Competition*, 1933.

Court A. (1939) : "Hedonic Price Indexes with Automotive Examples", p. 99-117, dans *The Dynamics of Automobile Demand*, New-York, General Motors Company.

Davis D. and Weinstein D. (2002), "The Mystery of the Excess Trade (Balances)", *American Economic Review*, May 2002.

Dixit, A. and J. Stiglitz (1977), "Monopolistic competition and optimum product diversity", *American Economic Review,* 67, pp. 297-308.

Dorfman, R., P. Samuelson, and R. Solow (1958), *Linear Programming and Economic Analysis*, New York: McGraw Hill.

Ethier (1982), "National and International Returns to Scale in the Modern Theory of International Trade", *The American Economic Review,* Vol. 72, No. 3. (Jun., 1982), pp. 389-405.

Feenstra R.C. (1988), *Empirical Methods for International Trade.* Cambridge, MA. MIT Press.

Feenstra R.C. (1992), "How costly is protectionism?", *Journal of Economic Perspectives*, 6:3, Summer 1992, pp. 159-78.

Feenstra, R. C. (1994), "New Product Varieties and the Measurement of International Prices", *American Economic Review*, Vol. 84, No. 1.

Feenstra R.C. (1998), « Integration of Trade and Disintegration of Production in the Global Economy », April 1998. *Journal of Economic Perspectives*, Fall 1998, pp. 31-50.

Funke and Ruhwedel (2001) "Product Variety and economic growth: empirical evidence from the OECD countries", IMF Staff papers, vol. 48, no.2.

Goolsbee A. and A. Petrin. 2001. The consumer gains from direct broadcast satellites and the competition with cable television. NBER Working Paper No. W8317, Cambridge, MA.

Griliches, Z. (1961), "Hedonic price indexes for automobiles: an econometric analysis of quality change". *The price statistics of the federal government*, 1961 (General Series, 73), New York: National Bureau of Economic Research. Reprinted in Griliches, Z. (ed.). *Price indexes and quality change: studies in new methods of measurement*, pp. 55-87, Cambridge, arvard University Press, 1971.

Harrigan J. (1995), "The Volume of Trade in Differentiated Intermediate Goods: Theory and Evidence", *The Review of Economics and Statistics*, Vol. 77, No. 2. (May, 1995), pp. 283-293.

Hausman J. (1997), "Valuing the Effects of Regulation on New Services in Telecommunications", in *Brookings Papers on Economic Activity, Microeconomics.*

Hausman, J. 1981. "Exact consumer's surplus and deadweight loss", *American Economic Review* 71(4) pp. 662-676.

Helpman, E. and P. Krugman (1985), *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition,and the International Economy* (Cambridge, MA: MIT Press, 1985).

Hicks, John R. (1942). "Consumers' surplus and index numbers". *Review of Economic Studies* 9(2) 126-137.

Hicks J.R. (1946), "The generalized theory of consumers's surplus", *Review of Economic Studies,* 13.

Hummels, David and Klenow, Peter J. (2002), "The Variety and Quality of a Nation's Trade", NBER WP #8712.

Klenow, Peter J. and Rodriguez-Clare, Andres (1997), "Quantifying Variety Gains from Trade Liberalization", mimeo, http://www.klenow.com/QuantifyingVariety.pdf

Krugman, P. (1979), "Increasing returns, monopolistic competition and international trade", *Journal of International Economics,* vol. 9.

Krugman, P. (1980), "Scale Economies, Product Differentiation, and the Pattern of Trade", *The American Economic Review*, Vol. 70, No. 5 (Dec., 1980), pp. 950-959.

Krugman P. (1995), "Growing World Trade: Causes and Consequences", *Brookings Papers on Economic Activity*, 1, p. 327–362.

Lancaster, K. (1971), *Consumer demand: a new approach.* New York, Columbia University Press, 1971.

Petrin, A. (2002), "Quantifying The Benefits Of New Products: The Case Of The Minivan," *Journal of Political Economy*, 2002, v110(4,Aug), 705-729.

Raff, D.M.G, Trajtenberg, M. (1995), "Quality-ajusted prices for the American automobile industry: 1906-1940". Feb. 1995 NBER Working Paper, 5035.

Rodríguez F. and D. Rodrik (2000), "Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence", newly revised, May 2000. Macroeconomics Annual 2000, eds. Ben Bernanke and Kenneth S. Rogoff, MIT Press for NBER, Cambridge, MA, 2001. pp. 261-325.

Romer P. (1994), "New Goods, Old Theory, and the Welfare Costs of Trade Restrictions," *Journal of Development Economics*, No. 43 (1994), pp. 5-38.

Rutherford T.F. and Tarr D.G. (2002), "Trade liberalization, product variety and growth in a small open economy: a quantitative assessment", *Journal of International Economics* 56 (2002) 247–272.

Sachs, J.D. and A.M. Warner (1995), "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity*, 1995:1, pp. 1-118.

Shapiro, M. and D. Wilcox (1996), « Mismeasurement in the Consumer Price Index: An Evaluation », dans Ben S. Bernanke et Julio Rotemberg, réd., NBER Macroeconomics Annual, Cambridge (MA), MIT Press, p. 93-142.

Schott, P. K. (2001), "Do Rich and Poor Countries Specialize in a Different Mix of Goods? Evidence from Product-Level U.S. Trade Data," NBER Working Paper #8492, September.

Spence, A.M. (1976) "Product Selection, Fixed Costs and Monopolistic Competition", *Review of Economic Studies*, 43, pp. 217-235.

Appendix 1:

Varieties defined as the increase in the number of origin countries

	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994
nb of firms	18001	18812	19496	19487	19870	20993	21446	21622	21663	21165
Average nb of country per firm	3.36	3.36	3.39	3.65	3.82	4.15	4.21	4.12	3.96	3.82

Contribution of varieties

	contribution of varieties firm level (in percent)				
	mean	Std dev	10%	median	90%
1994	-.72	16.5	-.62	0.0	.82
1995	.14	5.73	-.96	0.0	.56
1996	.14	5.30	-.86	0.0	.38
1997	.30	5.22	-.99	0.0	.37
1998	.16	5.48	-.99	0.0	.46
1999	1.0	7.4	-.91	0.0	.77
2000	.16	5.41	-.77	0.0	.36
2001	-.21	5.55	-.37	0.0	.81
2002	-.02	5.20	-.43	0.0	.42
2003	.06	4.57	-.38	0.0	.31

	TFP growth				
	mean	Std dev	10%	median	90%
1994	.28	9.3	-8.0	.36	8.6
1995	.11	8.4	-7.9	-.05	8.2
1996	-.32	8.2	-8.3	-.04	7.3
1997	.05	8.4	-7.7	.09	7.6
1998	.89	8.1	-6.5	.60	8.7
1999	1.2	8.0	-6.4	1.1	8.8
2000	.36	8.2	-7.9	.58	8.2
2001	-.87	8.5	-8.5	-1.1	7.3
2002	-.89	8.4	-9.1	-.7	6.8
2003	-.97	8.3	-8.6	-1.1	6.7

Sector	Proportion of firms in this sector (%)
Manufacture of food products, beverages and tobacco	4.37
Manufacture of consumers goods	6.09
Manufacture of motor vehicles	0.67
Manufacture of capital goods	7.19
Manufacture of intermediate goods	15.61
Energy	0.17
Construction	12.01
Trade	31.99
Transports	7.97
Services to businesses	13.91

First stage regression for table 2

	OLS
	variety growth firm level
variety growth- sector level	.379
	(13.78)**
Observations	175368

First stage regression for table 3

	OLS
	variety growth firm level
variety growth- sector level	0.0414
	(2.59)**
R2	0.000
Observations	175348

Predicted lambda ratios: First stage Tobit regressions (tables 7 and 8)
Dependent variable: import from country c

Country	Spain	UK	Germany	Italy	US
Exchange rate vis a vis c*	-4.54e+07 (-17.91)	-21926.73 (-1.82)	-418457.4 (-10.86)	-1.01e+09 (-17.99)	57007.66 (-8.32)
Nb of obs.	275278 145914 left-censored observations at M<=0	275278 160213 left-censored observations at M<=0	275278 103789 left-censored observations at M<=0	275278 76127 left-censored observations at M<=0	275278 126986 left-censored observations at M<=0

* t statistics are in parenthesis

First stage regression for table 7

	OLS
	Variety growth firm level
variety growth- sector level	0.138
	(5.13)
R2	0.0002
Observations	121253

First stage regression for table 8

	OLS Variety growth firm level
variety growth- sector level	0.1022975
	(4.15)
Sales (growth)	-.0323803
	(-7.09)
R2 (centered)	0.0004
Observations	121253

OLS
Variety growth firm level

Appendix 2. Capital stocks[18]

Let K_{HC} be the capital stock (gross), at historical costs, observed from balance sheet data and K_{CP} the gross capital stock at current price (unobserved), let D be total depreciation and fD, the flow of depreciation (both observed). The net subscript denotes that we refer to net values. I_t is investment and p_t is the price of investment. l is the asset life. We have:

$$K_{HC_t} = p_t I_t + ... + p_{t-l} I_{t-l}$$

$$K_{CP_t} = p_t I_t + ... + p_t I_{t-T}$$

$$Knet_{HC_t} = K_{HC_t} - D_t$$

$$fD_t = \frac{1}{l}\sum_{i=0}^{l} p_{t-i} I_{t-i} \text{ and } D_t = \frac{1}{l}\sum_{i=0}^{l} i p_{t-i} I_{t-i}$$

Capital stocks were first estimated by the perpetual inventory method, assuming geometric depreciation. Suppose a firm enters the database at year t_e. The average age of capital stock, a, is calculated as (see appendix 3):

$$a = l - \frac{Knet_{HC}}{fD}$$

with A being taken from macro-economic statistics.

The initial quantity of capital stock for a given firm in t_e is estimated by taking the net value of capital stock at historical costs in t_e divided by investment price in t_e-a. The physical capital stock for any $t>t_e$ is calculated through an incrementation procedure using the flows of investment and depreciation, which are both observed (permanent inventory method).

The second method is implemented in various works by the French National Institute for Statistics and Economic Studies (INSEE). The idea is to rewrite the capital stock at current price as follows :

---

[18] I am extremely imdebted to the members of the Banque de France Goods Market Network, supervised by Gilbert Cette, for participating in the construction of these stocks.

$K_{CP_t} \approx p_t I_t + (1 + \dot{p}) p_{t-1} I_{t-1} + \ldots + (1 + l\dot{p}) p_{t-l} I_{t-l}$ with $\dot{p}$ being some estimate for the average inflation rate of the investment deflator between t-A and t.

Hence : $K_{CP_t} \approx K_{HC_t} + \dot{p}(p_{t-1} I_{t-1} + \ldots + l p_{t-l} I_{t-l})$ and $K_{CP_t} \approx K_{HC_t}\left(1 + \dot{p}\dfrac{l \times D_t}{K_{HC_t}}\right)$

This last equation gives an estimate for the capital stock at current price.

Note that $\dfrac{l \times D_t}{K_{HC_t}}$ can also be interpreted as the average age of the capital stock.

Appendix 3. Total Factor Productivity

Permanent inventory method

The net value of physical capital stock is observed from balance sheet data and can

be expressed as: $\sum_{i=1}^{T}\left[p_{t-i}I_{t-i} - \left(\frac{i}{T}\right)p_{t-i}I_{t-i} \right]$, T being the asset life.

The total depreciation on the stock of this asset during t is also observed from

balance sheet data and can be expressed as:

$$flowD_t = \frac{1}{T}\sum_{i=1}^{T} p_{t-i}I_{t-i}$$

So

$$\frac{\text{net value of K stock}}{depreciation} = \frac{\sum_{i=1}^{T} p_{t-i}I_{t-i} - (1/T)\sum_{i=1}^{T} ip_{t-i}I_{t-i}}{(1/T)\sum_{i=1}^{T} p_{t-i}I_{t-i}}$$

$$= T - \frac{\sum_{i=1}^{T} ip_{t-i}I_{t-i}}{\sum_{i=1}^{T} p_{t-i}I_{t-i}}$$

$$= T - \text{Average age of capital stock}$$

Correlation matrix between TFP (Perpetual Inventory method) and TFP (Mairesse method)

1.0000	0.9405
0.9405	1.0000

Notes d'Études et de Recherche

175. J.-S. Mésonnier and J.-P. Renne, "Does uncertainty make a time-varying natural rate of interest irrelevant for the conduct of monetary policy?," September 2007.

176. J. Idier and S. Nardelli, "Probability of informed trading: an empirical application to the euro overnight market rate," September 2007.

177. H. Partouche, "Time-Varying Coefficients in a GMM Framework: Estimation of a Forward Looking Taylor Rule for the Federal Reserve," September 2007.

178. C. Ewerhart and N. Valla, "Financial Market Liquidity and the Lender of Last Resort," September 2007.

179. C. Ewerhart and N. Valla, "Forced Portfolio Liquidation," September 2007.

180. P.-A. Beretti and G. Cette, "Indirect ICT Investment," September 2007.

181. E. Jondeau and J.-G. Sahuc, "Testing heterogeneity within the euro area," September 2007.

182. J.-G. Sahuc and Frank Smets, "Differences in Interest Rate Policy at the ECB and the Fed: An Investigation with a Medium-Scale DSGE Model," September 2007.

183. J. Coffinet and S. Gouteron, "Euro Area Market Reactions to the Monetary Developments Press Release," October 2007.

184. C. Poilly, "Does Money Matter for the Identification of Monetary Policy Shocks: A DSGE Perspective," October 2007.

185. E. Dhyne, C. Fuss, H. Pesaran and P. Sevestre, "Lumpy Price Adjustments: a Microeconometric Analysis," October 2007.

186. R. Cooper, H. Kempf and D. Peled, "Regional Debt in Monetary Unions: Is it Inflationary?," November 2007.

187. M. Adanero-Donderis, O. Darné and L. Ferrara, « Deux indicateurs probabilistes de retournement cyclique pour l'économie française », Novembre 2007.

188. H. Bertholon, A. Monfort and F. Pegoraro, "Pricing and Inference with Mixtures of Conditionally Normal Processes," November 2007.

189. A. Monfort and F. Pegoraro, "Multi-Lag Term Structure Models with Stochastic Risk Premia," November 2007.

190. F. Collard, P. Fève and J. Matheron, "The Dynamic Effects of Disinflation Policies," November 2007.

191. A. Monfort and F. Pegoraro, "Switching VARMA Term Structure Models - Extended Version," December 2007.

192. V. Chauvin and A. Devulder, "An Inflation Forecasting Model For The Euro Area," January 2008.

193. J. Coffinet, « La prévision des taux d'intérêt à partir de contrats futures : l'apport de variables économiques et financières », Janvier 2008.

194. A. Barbier de la Serre, S. Frappa, J. Montornès et M. Murez, « La transmission des taux de marché aux taux bancaires : une estimation sur données individuelles françaises », Janvier 2008.

195. S. Guilloux and E. Kharroubi, "Some Preliminary Evidence on the Globalization-Inflation nexus," January 2008.

196. H. Kempf and L. von Thadden, "On policy interactions among nations: when do cooperation and commitment matter?," January 2008.

197. P. Askenazy, C. Cahn and D. Irac "On "Competition, R&D, and the Cost of Innovation, February 2008.

198. P. Aghion, P. Askenazy, N. Berman, G. Cette and L. Eymard, "Credit Constraints and the Cyclicality of R&D Investment: Evidence from France," February 2008.

199. C. Poilly and J.-G. Sahuc, "Welfare Implications of Heterogeneous Labor Markets in a Currency Area," February 2008.

200. P. Fève, J. Matheron et J.-G. Sahuc, « Chocs d'offre et optimalité de la politique monétaire dans la zone euro », Février 2008.

201. N. Million, « Test simultané de la non-stationnarité et de la non-linéarité : une application au taux d'intérêt réel américain », Février 2008.

202. V. Hajivassiliou and F. Savignac, "Financing Constraints and a Firm's Decision and Ability to Innovate: Establishing Direct and Reverse Effects," February 2008.

203. O. de Bandt, C. Bruneau and W. El Amri, "Stress Testing and Corporate Finance," March 2008.

204. D. Irac, "Access to New Imported Varieties and Total Factor Productivity: Firm level Evidence From France," April 2008.

Notes d'Études et de Recherche

175. J.-S. Mésonnier and J.-P. Renne, "Does uncertainty make a time-varying natural rate of interest irrelevant for the conduct of monetary policy?," September 2007.

176. J. Idier and S. Nardelli, "Probability of informed trading: an empirical application to the euro overnight market rate," September 2007.

177. H. Partouche, "Time-Varying Coefficients in a GMM Framework: Estimation of a Forward Looking Taylor Rule for the Federal Reserve," September 2007.

178. C. Ewerhart and N. Valla, "Financial Market Liquidity and the Lender of Last Resort," September 2007.

179. C. Ewerhart and N. Valla, "Forced Portfolio Liquidation," September 2007.

180. P.-A. Beretti and G. Cette, "Indirect ICT Investment," September 2007.

181. E. Jondeau and J.-G. Sahuc, "Testing heterogeneity within the euro area," September 2007.

182. J.-G. Sahuc and Frank Smets, "Differences in Interest Rate Policy at the ECB and the Fed: An Investigation with a Medium-Scale DSGE Model," September 2007.

183. J. Coffinet and S. Gouteron, "Euro Area Market Reactions to the Monetary Developments Press Release," October 2007.

184. C. Poilly, "Does Money Matter for the Identification of Monetary Policy Shocks: A DSGE Perspective," October 2007.

185. E. Dhyne, C. Fuss, H. Pesaran and P. Sevestre, "Lumpy Price Adjustments: a Microeconometric Analysis," October 2007.

186. R. Cooper, H. Kempf and D. Peled, "Regional Debt in Monetary Unions: Is it Inflationary?," November 2007.

187. M. Adanero-Donderis, O. Darné and L. Ferrara, « Deux indicateurs probabilistes de retournement cyclique pour l'économie française », Novembre 2007.

188. H. Bertholon, A. Monfort and F. Pegoraro, "Pricing and Inference with Mixtures of Conditionally Normal Processes," November 2007.

189. A. Monfort and F. Pegoraro, "Multi-Lag Term Structure Models with Stochastic Risk Premia," November 2007.

190. F. Collard, P. Fève and J. Matheron, "The Dynamic Effects of Disinflation Policies," November 2007.

191. A. Monfort and F. Pegoraro, "Switching VARMA Term Structure Models - Extended Version," December 2007.

192. V. Chauvin and A. Devulder, "An Inflation Forecasting Model For The Euro Area," January 2008.

193. J. Coffinet, « La prévision des taux d'intérêt à partir de contrats futures : l'apport de variables économiques et financières », Janvier 2008.

194. A. Barbier de la Serre, S. Frappa, J. Montornès et M. Murez, « La transmission des taux de marché aux taux bancaires : une estimation sur données individuelles françaises », Janvier 2008.

195. S. Guilloux and E. Kharroubi, "Some Preliminary Evidence on the Globalization-Inflation nexus," January 2008.

196. H. Kempf and L. von Thadden, "On policy interactions among nations: when do cooperation and commitment matter?," January 2008.

197. P. Askenazy, C. Cahn and D. Irac "On "Competition, R&D, and the Cost of Innovation, February 2008.

198. P. Aghion, P. Askenazy, N. Berman, G. Cette and L. Eymard, "Credit Constraints and the Cyclicality of R&D Investment: Evidence from France," February 2008.

199. C. Poilly and J.-G. Sahuc, "Welfare Implications of Heterogeneous Labor Markets in a Currency Area," February 2008.

200. P. Fève, J. Matheron et J.-G. Sahuc, « Chocs d'offre et optimalité de la politique monétaire dans la zone euro », Février 2008.

201. N. Million, « Test simultané de la non-stationnarité et de la non-linéarité : une application au taux d'intérêt réel américain », Février 2008.

202. V. Hajivassiliou and F. Savignac, "Financing Constraints and a Firm's Decision and Ability to Innovate: Establishing Direct and Reverse Effects," February 2008.

203. O. de Bandt, C. Bruneau and W. El Amri, "Stress Testing and Corporate Finance," March 2008.

204. D. Irac, "Access to New Imported Varieties and Total Factor Productivity: Firm level Evidence From France," April 2008.