Productividad total de factores, exportaciones y precios

(Total factor productivity, exports and prices)

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Para Matilde e Irene

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1 Resumen

En esta tesis se aborda el análisis de algunas hipótesis acerca de las relaciones entre el desempeño de las empresas, particularmente su condición de exportadoras, y un conjunto de características estructurales de las mismas, particularmente las medidas de la productividad total de los factores, en un contexto de un escenario macroeconómico altamente cambiante. El trabajo está basado en un conjunto de datos individuales de empresas manufactureras que viene de un período peculiar, en torno a una crisis de proporciones extraordinarias que en 2002 sufrió la economía de Uruguay así como las de otros países vecinos. El PBI cayó un 20 % y el peso se devaluó en alrededor de 100 %. Resulta interesante estudiar el conjunto de decisiones de las empresas y su desempeño, así como el impacto de la crisis en su funcionamiento en esas condiciones particulares.

El conjunto de trabajos que aquí se presenta tiene como referencia el trabajo con un conjunto de datos del sector manufacturero de Uruguay, que se ha logrado poner en funcionamiento a efectos de su análisis para la investigación económica. La Encuesta Anual de Actividad Económica del Instituto Nacional de Estadísticas del Uruguay recoge un conjunto de variables clave sobre producción, empleo, consumo intermedio, inversión de una muestra estratificada de empresas. Hasta ahora no había sido encarada la tarea de elaborar mecanismos de valoración a precios constantes de los principales elementos de la cuenta de producción de las empresas y obtener medidas del flujo de servicios del capital. Ello conduce a la posibilidad de estimar medidas de la productividad total de factores sobre la base de mediciones del valor bruto de producción de las empresas a precios constantes. La encuesta da seguimiento a un conjunto de unas 700 empresas anualmente entre 1997 y 2005, en particular a través de los años de la crisis entorno a 2002.

El proyecto está compuesto por tres trabajos. Uno busca desarrollar un modelo teórico del comportamiento de la empresa exportadora y de las decisiones de precios y de asignación de la la producción entre las ventas en el exterior y las domésticas, incluyendo simulaciones de su funcionamiento y cambios en el equilibrio de mercado en el contexto de shocks del tipo de cambio. El segundo busca ordenar un conjunto de evidencia sobre comportamiento de los precios relativos y de la respuesta exportadora de las empresas a shocks de tipo de cambio, en particular las decisiones de entrada y salida de los mercados de exportación y la asignación de la producción (export share o fracción de las exportaciones en los ingresos totales). El tercer trabajo busca estimar el impacto de la liberalización comercial en el período previo a la crisis en el desempeño de las empresas y en particular en la productividad total de factores.

Transmisión a precios domésticos en grandes devaluaciones

En este trabajo se estudia una variante de los modelos de comercio con empresas heterogéneas con el objetivo de analizar el impacto de grandes fluctuaciones en el tipo de cambio en las

decisiones de precios de las empresas y la asignación de la producción entre exportaciones y ventas domésticas. Las empresas difieren no solamente como es usual en este tipo de modelos en sus productividades, sino en una segunda dimensión que es el precio de exportación que reciben. Las empresas se encuentran en régimen de competencia monopolística en el mercado interno, pero resultan tomadoras de precios en los mercados internacionales. El tipo de cambio es exógeno a sus decisiones. En lugar de considerar que existe una tecnología de costo marginal constante, se supone una tecnología cóncava para la producción conjunta de exportaciones y producción para el mercado interno, a un costo marginal creciente.

El modelo en su versión no restringida, obtiene una transmisión (*pass-through*) completa para los movimientos en el tipo de cambio hacia los precios domésticos, y una intensificación de la actividad exportadora con un aumento de la participación de las exportaciones en las ventas totales. Buscando una explicación para la transmisión incompleta hacia los precios domésticos, se introduce una restricción de exportaciones que afecta al menos a algunas empresas, por la cual éstas no pueden exportar los niveles que desearían hacerlo. La restricción de exportaciones está basada en la necesidad de las empresas de financiar con anticipación sus costos fijos y variables de comercio internacional.

Una devaluación vuelve más aguda la restricción financiera de las empresas, por lo que algunas de las empresas dejarán de exportar o reducirán las cantidades en las que lo hacen. Las empresas restringidas tenderán a incrementar más la producción destinada al mercado interno, y como resultado eso producirá que su precio doméstico nos suba en la misma medida que el precio de las exportaciones o aún baje, con respecto a la situación sin restricciones. Como resultado surge una posible explicación al resultado observado de que los cambios en la participación de las exportaciones en las ventas totales y el precio relativo de exportación de las empresas que enfrentan esta restricción presentan una correlación negativa.

El modelo no presenta una forma analítica cerrada, pero es posible resolver numéricamente para los agregados de equilibrio dados valores de los parámetros básicos, y evaluar mediante simulación los impactos de cambios en el tipo de cambio y los efectos de la situación con y sin restricción. En el trabajo se presenta un ejercicio de simulación en que se calcula las decisiones óptimas para un conjunto hipotético de firmas distribuidas en una grilla de valores de productividad y precios de exportación. Se obtiene las exportaciones y ventas domésticas en cada situación, calculando los beneficios en cada caso y se clasifica a las empresas en cuatro subconjuntos: salida del mercado, empresa no exportadora, exportadora con restricciones y exportadora sin restricciones.

El modelo recupera el resultado de una transmisión o *pass-through* completo en el caso de exportadoras no restringidos. En el caso del exportador restringido se observa que los precios divergen, en particular en el agregado se observa una disminución de los precios domésticos. por tanto la transmisión es incompleta. Se produce el resultado de que aquellas empresas en que el precio relativo de las exportaciones es mayor son aquellas en que las exportaciones se reducen o aumentan menos.

Desempeño exportador, precios y productividad

Este trabajo aborda la estimación econométrica de ecuaciones para indicadores de desempeño exportador de las empresas, en particular la condición de exportadora (margen extensivo o entrada-salida del mercado exportador), y la participación de exportaciones en ventas totales (margen intensivo). Se busca capturar el impacto de cambios en el entorno, en particular cambios en precios relativos y características estructurales de las empresas. Las medidas de desempeño y particularmente los indicadores de productividad total de los factores a nivel micro dependen de las elecciones de precios base para obtener mediciones a valores a precios constantes en las que se basan las estimaciones de función de producción. A su vez de estas estimaciones surgen los índices de productividad total de los factores a nivel de empresa. La deflactación separada exportaciones y ventas domésticas es particularmente sensible a la evolución divergente de precios domésticos y de exportación.

El trabajo presenta el marco del comportamiento de las empresas en las que, bajo algunos supuestos, las empresas que se encuentran bajo restricciones a la actividad exportadora reaccionan frente a cambios en el tipo de cambio. Dichas restricciones pueden provenir de la necesidad de financiar de antemano los costes fijos y variables del comercio. También es posible pensar en restricciones cuantitativas no arancelarias de parte de socios comerciales regionales que se encuentren en situaciones de crisis. En ambos casos una devaluación al mismo tiempo que vuelve atractiva la actividad exportadora, exacerba las restricciones y puede observarse efectos de signo contrario en los precios domésticos y de exportación para una misma empresa, así como cambios en la composición de la producción entre ventas doméstica y en el mercado exterior.

Se trabaja con datos de Encuesta Anual de Actividad Económica 1997-2005 del Instituto Nacional de Estadística de Uruguay (INE), un panel de empresas que incluye registros anuales de las ventas domésticas y de exportaciones, producción, empleo, capital y consumo intermedio, incluyendo energía, agua, combustibles y materiales. Para controlar por el efecto diferencial de los precios del producto se construye un deflactor específico de la empresa separando ventas domésticas y de exportación, usando la estructura de las ventas y ponderando índices a nivel sectorial de los precios del productor y de precios de exportaciones FOB en dólares. Los valores a precios de diferentes años base presentan variaciones importante y algunos resultados tradicionales se revierten, por ejemplo los diferenciales de productividad en favor de las empresas exportadoras que son usuales en la literatura se vuelven negativos si los precios base son los de bajo tipo de cambio real.

Nuestra objetivo es la estimación de los determinantes de la condición de exportador y del coeficiente de intensidad exportadora o *export share*. Para la primera variable se adopta una especificación *probit* dinámica. La condición de exportador en el período anterior es altamente significativa lo que se interpreta como evidencia de la importancia de los costes fijos en la decisión de exportar. Encontramos que en la ecuación el precio relativo tiene un signo negativo pero no resulta estadísticamente significativo. Para el coeficiente de intensidad exportadora se tiene en cuenta que la variable dependiente se encuentra acotada al intervalo $[0, 1]$ (aunque en nuestro caso se estima para la submuestra de exportadores), y se usa el procedimiento de estimación *logit* fraccional propuesto por Papke y Wooldridge (2008). Se obtiene un efecto del precio relativo de exportación significativo y negativo, aún controlando por el precio de las exportaciones.

El impacto de la protección comercial en la productividad

Este trabajo intenta analizar en qué medida existen ganancias de productividad asociadas a las medidas de liberalización comercial. Tradicionalmente se ha argumentado que los procesos de apertura producen ganancias estáticas del comercio, pero la literatura más reciente ha destacado los beneficios dinámicos que pueden surgir de ganancias de productividad en las economías en desarrollo. La literatura basada en los modelos de comercio de empresas heterogéneas enfatiza los mecanismos de selección a través de los cuales la reasignación de recursos puede conducir al crecimiento de la productividad.

El proceso de política comercial de Uruguay es un caso interesante de estudio. En los tempranos años 90 se profundizó el proceso de liberalización comercial que combinó reducciones unilaterales de aranceles con integración regional en el marco del Mercosur. Nuevos datos están disponibles para evaluar el impacto de la liberalización basándose en datos de protección comercial a nivel de empresa en lugar de los datos usuales a nivel de sector. En este trabajo se estudia el efecto de la protección en la industria manufacturera usando un panel de empresas entre 1988 y 2001. Se estima la productividad total de los factores de las empresas adaptando las propuestas de DeLoecker (2011) (DL en adelante) y se relacionan con indicadores de protección comercial en los productos y en los insumos de la empresa, construidos como el arancel promedio de las clases del Sistema Armonizado que contiene los productos y los insumos de la empresa, respectivamente.

Sobre la base de las ideas de Klette y Griliches (1996), DeLoecker (2011) propone un método de estimación que supera las limitaciones que surgen de que al no poder observarse las cantidades físicas producidas los trabajos de estimación de las productividades se basan en los datos de ventas de las empresas, los cuales muchas veces son deflactados usando índices de precios agregados del sector, lo que puede conducir a estimaciones sesgadas en la medida que el error en los precios (o diferencia entre el precio de la empresa y del sector) se encuentre correlacionado con las decisiones de la empresa sobre el uso de factores de producción. Además, las estimaciones de productividad contienen variación de los precios y la demanda, la que potencialmente introduce relaciones espúreas entre la productividad que se mide y la apertura comercial a través del impacto de la liberalización en los precios y la demanda. De esta manera, para que pueda ser identificado el efecto de la protección en la productividad, además de por la endogeneidad en el uso de factores es preciso controlar por los precios inobservados y los shocks de demanda.

Nuestra contribución consiste en adaptar el método propuesto por DeLoecker (2012) para controlar por dicha variación. En ese espíritu descomponemos el shock de demanda en una parte inobservable y otra observable, usando la estructura de las ventas para obtener medidas de los aranceles a nivel de empresa, los cuales desplazan la demanda de la empresa. A su vez, extendemos el marco de análisis para incorporar la protección en los insumos de materiales y materias primas además de en los bienes finales. Consideramos dos canales por los que esto tiene lugar: uno es la demanda de insumos, y el otro es un efecto en la productividad (por ejemplo por la vía del acceso a una canasta de insumos más variada o de mayor calidad). Usando la estructura de las compras de materiales de la empresa por producto construimos medidas específicas a la empresa de la protección arancelaria en los insumos. Para un país pequeño entre vecinos muchas veces superiores en tamaño, en un marco de integración regional se puede pensar que los aranceles son razonablemente exógenos.

Se realiza un procedimiento de estimación de los coeficientes de la función de producción de la empresa en dos etapas, donde la productividad inobservable es aproximada no paramétricamente en una primera etapa. Nuestras estimaciones de productividad controladas son la variable dependiente de una segunda etapa en que se estima el impacto de la protección. Se obtiene un impacto significativo, medido por los aranceles de nación más favorecida, de la protección arancelaria en la productividad total de los factores de las empresas uruguayas en el período en que la apertura comercial –tanto bilateral como en el marco del Mercosur– fue más intensa. Las reducciones de aranceles sobre los productos de las empresas incrementan la productividad, mientras que se obtiene el efecto inverso con los aranceles en los insumos: reducciones de los mismos reducen significativamente la productividad total de los factores. Esta asociación de una más alta protección a los insumos con mayor productividad puede asociarse al argumento de Corden (1971) sobre la protección efectiva: menores aranceles sobre los insumos incrementan la protección efectiva, por lo que los incentivos de las empresas para cambiarse a más eficientes técnicas de producción podrían reducirse.

2 Introducción

En este capítulo se busca establecer los objetivos fundamentales de la tesis, algunas características comunes de los distintos trabajos que la integran, y los objetivos específicos que se persiguen en cada uno de ellos. Todos ellos tienen un temática común, en que la unidad de estudio es la empresa, y la herramienta es el análisis microeconómico. Sin embargo se toma en cuenta el conjunto de variables que constituyen el entorno en el que estas empresas se mueven, y se busca contribuir al estudio de los equilibrios que surgen de la interacción de las empresas en ese ambiente común.

Todos los trabajos a su vez se encuentran vinculados por aquellas características que destacan en la actividad de la empresa. En todos ellos, la productividad es el elemento central del análisis, el elemento constitutivo que diferencia a una empresa. De la interacción de esta característica estructural con el entorno, y con las restricciones que le impone la actividad de las demás empresas, surgirán los elementos del desempeño que son objeto del análisis. En este sentido hay una segunda característica común a los trabajos, y es que en todos ellos se hace foco en la capacidad de las empresas de desempeñarse en el mercado exterior. En la literatura económica se ha señalado en forma insistente que la contribución de las empresas al desarrollo económico está fuertemente vinculada a la capacidad de vincularse a la actividad exportadora. Esto tiene un particular énfasis en el caso de las economías en desarrollo.

El enfoque más reciente ha ido descansando menos en la estrategia de establecer el comportamiento de una empresa representativa y más en dar lugar a dimensiones en las cuales las empresas difieren en características estructurales. Particularmente las contribuciones basadas en Melitz (2003) introducen una distribución de las empresas en el eje de la productividad, de manera que los modelos procesan las decisiones individuales de las empresas sobre la base de esta características, y se agrega finalmente los comportamientos individuales para dar lugar dan lugar a las distribuciones observadas de los mismos.

Dicha estrategia descansa a su vez en la creciente disponibilidad de datos de empresa en los que se puede poner a prueba estas ideas y estrategias de modelización. En el caso de esta tesis, se trata de una oportunidad para poner en funciones en el contexto de la investigación académica una base de datos relativamente poco usada proveniente de una economía en desarrollo como es la de Uruguay. El Instituto Nacional de Estadística ha recogido durante años las Encuestas Anuales, con cuestionarios detallados acerca de producción, empleo, consumo intermedio e inversión, que han permitido un acercamiento a las características estructurales del sector manufacturero uruguayo, produciendo fundamentalmente estadísticas a nivel sectorial. Sin embargo estos datos y las publicaciones a que dieron lugar consistían en información agregada y en valores corrientes, lo que no permitía el aprovechamiento pleno de la riqueza estadística contenida en la heterorgeneidad de los datos ni en la posibilidad de un análisis en la dimensión temporal a través de series a precios constantes.

Por lo tanto una contribución importante de esta tesis es la puesta en funcionamiento de la base de datos como un panel con criterios de valuación y definición uniformes, un trabajo que en sí mismo tal vez no se nota y que sin embargo está detrás de todas las estimaciones y de todas las aproximaciones empíricas. Esto incluye la búsqueda de deflactores, la homogeneización de criterios de valuación, cambios en el muestreo y en la estratificación, tratamiento de incorporaciones y salidas de la muestra, cambios en criterios de clasificación, entre otras. La existencia de los datos y su disponibilidad para futuros trabajos es un logro en sí mismo.

Un tercer elemento que puede destacarse es que el período al que refieren estos datos es de crisis y la temática de investigación tiene que ver con grandes fluctuaciones, en particular los grandes cambios macroeconómicos, los shocks de tipo de cambio, las crisis financieras y la liberalización comercial. Los trabajos buscan desentrañar los mecanismos económicos en épocas en las que todo parece inestable, tratando de detectar la regularidad en un entorno que parece completamente cambiante.

A su vez, los trabajos buscan adaptar los enfoques teóricos a la situación que caracteriza de un modo general a las economías en desarrollo. En particular, al desarrollar un intento teórico sobre la reacción de las empresas en sus precios y cantidades ante cambios en el tipo de cambio, se adopta una perspectiva de economía pequeña, concentrada en un número de bienes de exportación reducido y poco diversificado, con escaso poder de mercado. La estrategia de construcción del modelo establece a su vez un rol importante para las restricciones financieras y en general cuantitativas a la actividad exportadora como la base de la explicación de las peculiaridades de la formación de precios y asignación de las ventas entre exportaciones y mercado doméstico.

Cada uno de los tres trabajos que integran el proyecto tiene a su vez sus objetivos particulares, que se desarrollan en profundidad en cada uno de ellos. Como fue mencionado, el primero intenta desarrollar un modelo teórico del comportamiento de la empresa exportadora y de las decisiones de precios y de asignación de la la producción entre las ventas en el exterior y las domésticas ante variaciones en el tipo de cambio. El segundo busca generar estimaciones econométricas de la respuesta exportadora de las empresas cuando el tipo de cambio se mueve, en particular las decisiones de entrada y salida de los mercados de exportación y el *export share* o relación entre exportaciones el ingresos totales. El último intenta estimar el impacto de la caída en los aranceles del producto final y de los insumos en la productividad total de factores, lo que enfatiza el efecto en el potencial de crecimiento a largo plazo además de las ganancias estáticas de comercio.

3 Domestic price passthrough under large devaluations

Resumen

En este trabajo se estudia un modelo de comercio con empresas heterogéneas para analizar la determinación de los precios y las decisiones de asignación de la producción entre las exportaciones y las ventas domésticas, frente a cambios importantes en el tipo de cambio y en las condiciones financieras. Las empresas son tomadoras de precios en el mercado externo, a la vez que compiten monopolísticamente en el mercado interno. Se busca una explicación para una transmisión (*pass-through*) incompleta desde el tipo de cambio a los precios domésticos. Se introduce una restricción basada en los requerimientos para las empresas de financiar los costos fijos y variables de exportar. Los exportadores restringidos tienden a incrementar más su producción para el mercado doméstico, y como resultado incrementan menos o incluso disminuyen el precio doméstico con relación al caso sin restricciones. Como resultado se obtiene que los cambios en la participación de las exportaciones en ventas totales y los cambios en el precio relativo de las exportaciones se encuentran negativamente correlacionados para los exportadores restringidos.

Abstract

We study a trade model of heterogeneous firms to analyze pricing and output allocation decisions between exports and domestic sales, in the face of large changes in the exchange rate and changing financial conditions. Firms are price takers in the export market, while producing in monopolistic competition in the domestic market. We look for an explanation for incomplete *pass-through* from the exchange rate to domestic prices. We introduce an export constraint based on the firms need to finance trade costs. Constrained exporting firms tend to increase domestic production more, and as a result they will increase less their domestic price than in the unconstrained case. As a result we obtain that changes in the export share and changes in the relative export price of constrained exporters are negatively related.

3.1. Introduction

In this paper we develop a model to study firm's pricing and output allocation decisions between exports and domestic sales. We seek to explain behavior in the face of changes in the exchange rate and in financial conditions. We model heterogeneous firms in terms of their productivity and the international price they face. We consider firms price takers in the export market, while they are monopolistically competitive in the domestic market. This approach is suitable for economies that export a set of relatively less differentiated goods, based on agricultural comparative advantage, in which they remain a very small fraction of world supply.

Our contribution is to provide an explanation for a relatively little documented fact, i.e. there is a negative association between the export share in total sales, and the relative export price, i.e. the ratio between export and domestic prices at the firm level. Both variables are positively associated at the aggregate level.

Our explanation relies on incomplete *pass-through* from the exchange rate to domestic prices by exporting firms. Our model introduces a firm export constraint, motivated as arising from the requirement to firms to finance in advance export fixed and variable costs. Constrained firms do not get to export what they optimally would in absence of constraints. As they displace output to the domestic market, the domestic price decreases relatively to the export price. Larger changes in the export share are thus associated with smaller increases in the relative export price.

Section 2 introduces the related literature and the descriptive information that motivates our analysis. Section 3 studies model economy, first the unconstrained model, and then constrained firm behavior. Section 4 is dedicated to market equilibrium. Section 5 presents some numeric equilibriums computed and analyzed, while section 6 concludes.

3.2. Motivation

Some papers in the recent literature relate to the subject of exporter pricing and output allocation. Berman, Martin and Mayer (QJE, 2012) analyzes the reaction of exporters to real exchange rates. In their framework there is market power of large firms in the export market. They note that the impact of exchange rate movements on aggregate exports is weak as results from estimated elasticities in the literature. Their view is that more productive and larger firms absorb exchange rate fluctuations in their markups, hence exports remain less sensitive. Key to their argument is the response of exports to specific destination markets to the respective bilateral exchange rates. The models they review all include pricing to market by exporting firms.

A paper by Berman, Berthou and Héricourt (2015) studies the relationship between French firms' exports and domestic sales. They find that exports and domestic sales are complementary at the firm level. This paper does not provide however a model seeking to explain such facts.

The case of Uruguay from 1997 to 2005 is useful to motivate our research question. This period comprises a financial crisis, large swings in the exchange rate, and changes in relative prices. In 1999, Uruguay faced a 66 % depreciation of the Brazilian Real against the dollar; then, following the December 2001 financial Argentinian crisis, a 100 % devaluation of the Uruguayan peso against the dollar in 2002, at the time that the Argentinian peso devaluated around 400 %.[1] In figure 3.1 we show the exchange rate of the Uruguayan peso *vis a vis* other currencies.

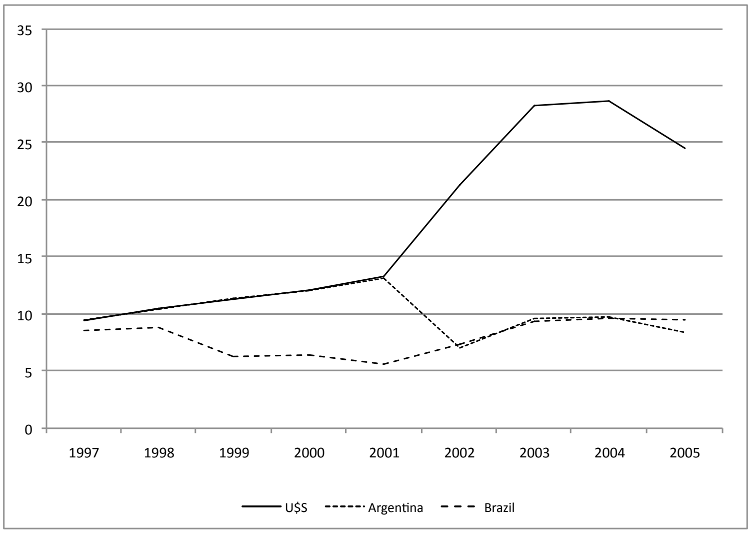


Figura 3.1: Uruguay: exchange rate (pesos) against US, Argentina and Brazil

To analyze firm behavior in that period, we use the Annual Economic Activity Survey of the National Statistics Institute of Uruguay[2] and combine firm and aggregate sector data. Firm-level data include revenues, employment, domestic and imported purchases of intermediate inputs by product code, imported and domestic capital expenditures and domestic and export sales by product code. With respect to prices, we rely on indexes published by the Central Bank of Uruguay that record free on board export prices denominated in dollars, and prices of domestically sold output, both at the sector level.[3] We calculate the export price index in domestic currency by multiplying by an index of the dollar value. At the firm level, we construct implicit price indexes by deflating separately each firm's export and domestic sales, by product, using sector indexes. Firm level price indexes will separate of sector indexes when they produce goods from different sectors.

We also compute a firm level indicator of the **relative export price** –defined in what follows as the ratio of export to domestic prices–. We find that generally all exporting firms also sell in the domestic market, i.e. firms completely specialized in the export market are rare. Different views or assumptions on firm behavior lead to different interpretations of such indicator.

Between 1997 and 2005, the relative export price of the Uruguayan manufacturing sector and the **export share** of manufacturing –measured as the ratio of exports to total sales- show a close pattern. As can be observed in Figure 3.2, both series are positively correlated.[4] In particular, the 2002 devaluation of the Uruguayan peso against the dollar is reflected in a large increase of the relative export price followed by a major raise of the export share.

[1] All these nominal changes took place concomitantly with a real GDP decline of almost 20 % over three years starting in 1999. Exports stopped growing in 1998/1999 to decrease more than 5 % between 2000 and 2002, and recovered from then on to strongly grow in the following decade.

[2] Encuesta Anual de Actividad Económica, INE, Uruguay.

[3] For sectors exporting their production to neighbors Argentina and Brazil the valuation reflects both price in the local currency and the exchange rate of that currency vis a vis the dollar.

[4] We show the ratio of exports to gross revenue for the whole manufacturing sector from National Accounts and the average relative output price for the exporting firms in our sample.

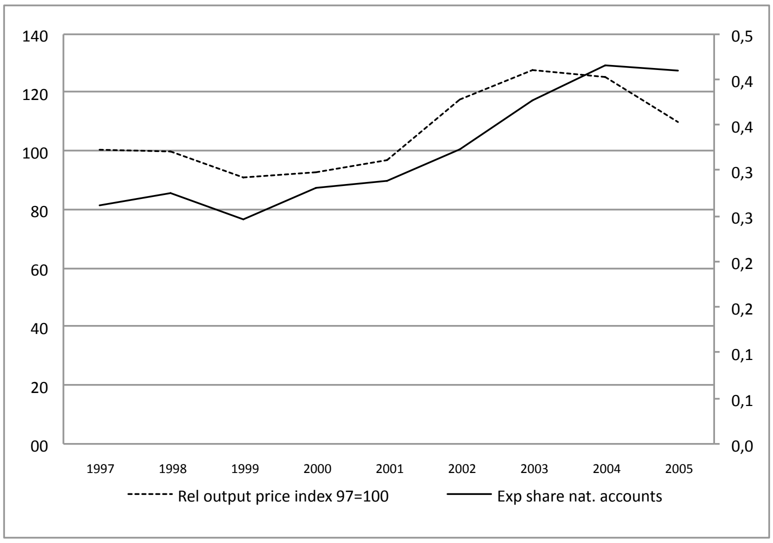


Figura 3.2: Relative Output Price and Export Share in Manufacturing

If we interpret these observations from the point of view of a model with representative firms, this correlation indicates that on the one hand, the exchange rate *pass-through* is not complete, i.e. the domestic price of exporters does not fully accomodate the exchange rate shock, and on the other hand, there is reallocation of output from domestic sales towards the export market, i.e. that at the firm level there is an association between more exports and a high relative output price.

In Table 1 we show relative prices for our sample of manufacturing firms and bilateral exchange rates with Uruguay's main trade partners. The Central Bank's index of export prices in dollars is based on customs declarations, and prices of transactions not held in dollars are converted into dollars. It is interesting that in 1999 Brazil devaluated the Real, while Argentina maintained its currency board with a 1 to 1 parity to the U$S dollar in 2000 and 2001.

Table 1
Relative export price p_x/p_d, export and domestic prices,
export dollar price and bilateral exchange rates
(indexes base year = 1997)

Year	Relative export price	Export price	Domestic price	Export dollar price	US dollar	Brazilian real	Argentine peso
1997	100,0	100,0	100,0	100,0	100,0	100,0	100,0
1998	99,4	108,6	109,9	98,0	110,9	103,2	110,9
1999	91,6	102,6	113,0	85,5	120,1	73,7	120,1
2000	93,0	106,9	115,9	83,4	128,1	74,7	128,3
2001	106,4	115,1	109,9	81,6	141,0	66,3	139,6
2002	137,0	173,3	132,4	77,1	224,8	86,8	74,8
2003	149,8	242,3	172,0	81,2	298,3	109,2	102,4
2004	149,4	263,7	189,5	86,9	303,5	113,6	104,0
2005	131,4	230,1	188,5	88,9	258,8	111,5	89,1

Source: INE database

So in the first years of our sample period we observe a 30 % revaluation of the exchange rate *vis a vis* Brazil. Both a view in which firms retain some degree of market power in the Brazilian market, and one of firms as price takers in the export market would have implied that prices in Brazilian reals should have gone up. Export price indexes denominated in dollars are a weighted average of transactions denominated in reals, in Argentinian pesos (convertible to dollars one for one) and in dollars. Exporters to Brazil obtain less dollars for their Brazilian reals. Exchange rates to the U$ Dollar and Argentinian peso go up 8 % in these years, and average export prices in dollars fall. As pointed by BER (2007) devaluation took place in Uruguay in June 2002, but there is substantial change in the exchange rate before such date, due to the the January 2002 devaluation in Argentina. Our yearly averages pick all of such variation.

The most striking change takes place in 2002-2003, when the U$ dollar exchange rate more than doubles. Dollar prices would be expected to go down, which they do, but only in 2002, and very modestly with respect to the large exchange rate swing.

With respect to *pass-through*, domestic prices continue to go up throughout the period (with the exception of 2001), and on average the relative price increases between 1999 and 2004. There is variation at the sector level in the domestic price response, and much less in their export dollar prices (and hence in export prices in domestic currency).

From a theoretical point of view, both price taking and monopolistically competitive exporters would have accomodated exchange rate variations in their domestic prices (since it is less controversial to assume negatively sloped firm demand curves in the domestic market). So we will highlight factors separating domestic and export prices. Our view is that quantitative constraints to exports play a role, particularly in the context of the financial crisis and non tariff barriers from neighboring economies.

The correlation of aggregate export share and relative output price would suggest output reallocation by firms from domestic to export sales. However, as we can see in Figure 3.3, at the micro level, increases in the export share of firms are not clearly associated to relative output price increases, and if anything, they tend to be slightly negatively correlated. [5]

In the next sections we analyze our firm model. The explanation we explore for the above results is based on firms being constrained in their export levels, hence differing in their abilities to exploit the opportunities for exporting arising from exchange rate movements. If firms enjoy to some extent market power in both domestic and export market, changes in markups will explain less than full *pass-through* and pricing-to-market behavior. If markups are fixed or firms are price takers in the export market, this would imply that changes in the exchange rate would be passed to domestic prices. Relative export prices will not be altered significantly, but as quantity decisions are linked via a common marginal cost, larger domestic prices will imply less domestic sales and an increase in the export share. If firms however are constrained to export up to their new optimal quantities (assume for instance credit constraints arise from a devaluation coincident with a financial crisis, or from nontariff barriers from trade partners), there will be less exchange rate *pass-through* and less response of the export share.

[5] FIgure 3.3 shows relative output price changes and export share changes, at the firm level, between 1999-2001 and 2003-2005, *i.e.* before and after 2002 when the Uruguayan peso devaluated 100 % wrt the dollar.

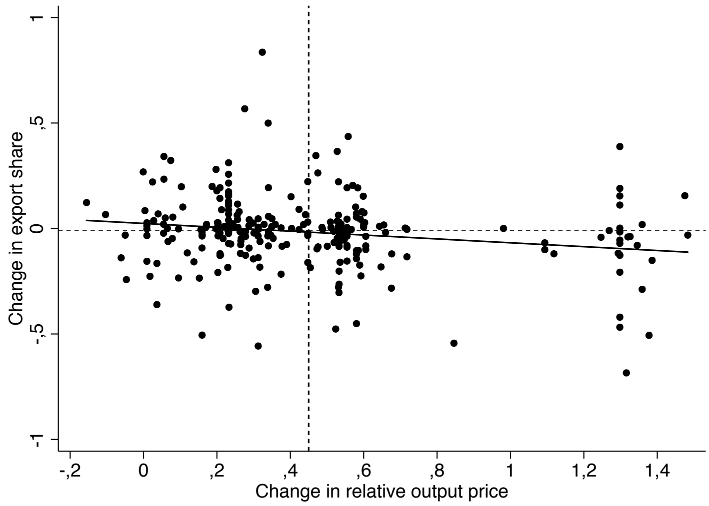


Figura 3.3: Changes in relative export price and export shares

3.3. Model Economy

Preferences. In the domestic economy, preferences for domestically produced goods of the representative individual are

$$c_d = \left(\int q_{dj}^{\rho} dj \right)^{\frac{1}{\rho}},$$

where q_{dj} is domestic consumption of variety j and $\rho \in (0,1)$ is positively related to the elasticity of substitution. Consumers maximize it subject to a standard budget constraint. For simplicity, we assume that domestic firms face no (monopolistic) competition from foreign varieties. Under this assumption, the domestic aggregate price faced by domestic firms does not depend on the pricing behavior of foreign firms. Devaluations then do not directly affect the domestic price through the price of imported goods.

At given prices p_{dj}, measured in the domestic currency, the optimal inverse demand of domestic variety j is

$$p_{dj} = \hat{P}_d \, q_{dj}{}^{\rho-1},$$

where $\hat{P}_d = P_d c_d^{1-\rho}$ and

$$P_d = \left(\int p_{dj}^{\frac{\rho}{\rho-1}} \; dj \right)^{\frac{\rho-1}{\rho}} .$$

Domestic firms. All variables associated to firm j are firm specific, with a few exceptions made explicit later, but we will omit index j to simplify notation. Indeed, firms face all the same parameters (apart from productivity z and the export price $p_{\$x}$). A firm produces q_d and q_x for the domestic and foreign markets, respectively, and faces a variable trade cost $e\tau_{\$}$, where e is the nominal exchange rate and $\tau_{\$}$ is variable trade costs in foreign currency units. $\tau_{\$} > 0$ is exogenously given. Firms also face fixed production and export costs. The fixed production cost is equal to wh_p, where w is the equilibrium nominal wage and h_p an exogenous amount of labor. The fixed export cost is given by $ef_{\$}$, where $f_{\$} > 0$ is an exogenous fixed cost measured in foreign currency. All firms share the same fixed production and export costs.

Firms' production technology is

$$q_d + q_x = z^{1-\alpha}\, \ell_p^{\alpha}$$

where ℓ_p is the total amount of flexible labor required to produce $q_d + q_x$; $\alpha \in (0,1)$.

Firms operate in the international market under perfect competition; they take the export price $ep_{\$x}$ as given, where $p_{\$x}$ is the international price of exported goods, measured in foreign currency. In the following, we denote by $p_{\$} = p_{\$x} - \tau_{\$}$ the export price net of variable trade costs.[6] For convenience, we depart from the assumption of iceberg-type trade costs.[7]

We also introduce a quantitative export constraint. i.e.

$$q_x \leq \bar{q}_x(z).$$

Below we develop a more formal derivation of this constraint in terms of financial requirements of firms to pay for export costs, so that liquidity constraints result in an export constraint $\bar{q}_x$ which positively depends on firms's productivity z.[8] As a consequence, firms may be operative in the export market but unable to expand their exports above a firm specific threshold.

Firms are characterized by a productivity z and an export price $p_{\$}$, and face the following problem:

$$\pi(z) = \max_{q_d, q_x}\ \hat{P}_d\, q_d^{\rho} + ep_{\$} q_x - z^{\frac{\alpha-1}{\alpha}} (q_d + q_x)^{\frac{1}{\alpha}} w$$

s.t.

$$q_x \leq \bar{q}_x(z),$$

where the aggregates P_d and c_d, the export price $ep_{\$}$, and the nominal wage w are taken as given.

The first order conditions for this problem are

$$p_d = \underbrace{\frac{1}{\rho}}_{\text{markup}}\ \underbrace{\frac{z^{\frac{\alpha-1}{\alpha}}}{\alpha} (q_d + q_x)^{\frac{1-\alpha}{\alpha}}\, w}_{\text{marginal production cost}}$$

and

$$ep_{\$} = \frac{z^{\frac{\alpha-1}{\alpha}}}{\alpha} (q_d + q_x)^{\frac{1-\alpha}{\alpha}}\, w + \eta,$$

where the Kuhn-Tucker multiplier associated to the export constraint, $\eta \geq 0$, is firm specific.

Combining the optimal conditions

$$p_d = \frac{ep_{\$} - \eta}{\rho}.$$

[6] We rule out that foreign competitors enter the local market rendering it competitive as well. Some arguments could justify this assumption. We may assume that the technology available to produce any particular variety is free but there is an adoption cost. A small open economy would be defined here as a size that reduces the number of firms per variety to one at equilibrium.The domestic economy trades with large economies, where the number of competitors is large enough to the equilibrium be close to competitive. Another reason may be in the nature of differentiation, because of preferences or the cost of differentiating a product.

[7] This will play a role in our definition of financial constraints below.

[8] Similar arguments can be found in Chaney (2016) and Manova (2013).

Firms facing a stringent export constraint will set a low domestic price relative to their export price to spill constrained exports over the domestic market.

3.3.1. Unconstrained Economy

In what follows we analyze firm behavior for non exporting (domestic) and exporting (constrained and unconstrained) firms. The general setup of the market equilibrium of the model is discussed in Appendix B. A firm's draw of $(z, p_\$)$ determines whether the firm exits the market, sells its output only domestically, or it sells it both domestically and in the export market. The sorting into these subsets is dependent on the comparison between the profits that would obtain from selling only domestically $\pi_n(z, p_\$)$ and those it would obtain selling both in the domestic and in the export market $\pi_u(z, p_\$)$.

Only firms with positive profits will remain active. A firm for which $\pi_n < 0, \pi_u < 0$ would exit the market. A firm for which $\pi_n > 0, \pi_n > \pi_u$ would sell only domestically, while a firm with $\pi_u > 0, \pi_u > \pi_n$ would be an exporter (selling also in the domestic market). We analyze first unconstrained firms, and introduce the export constraint later on.

Non exporter and exporter profits Both types of firms face the same problem above. In the case of **non exporters** they optimally decide to to have $q_x = 0$. Then, their optimal domestic supply is characterized by

$$q_d(z) = \left(\alpha\rho\, z^{\frac{1-\alpha}{\alpha}} \, \frac{\hat{P}_d}{w}\right)^{\frac{\alpha}{1-\alpha\rho}}.$$

Non exporters simply equalize their marginal income in the domestic market to marginal cost. Notice that q_d is homogeneous of degree zero in nominal variables $\hat{P}_d$ and w. As expected, more productive firms produce more, and consequently charge a lower price p_d, where

$$\boxed{\frac{p_d(z)}{\hat{P}_d}} = q_d(z)^{\rho-1} \boxed{= \left(\alpha\rho\, z^{\frac{1-\alpha}{\alpha}} \, \frac{\hat{P}_d}{w}\right)^{\frac{\alpha(\rho-1)}{1-\alpha\rho}}}.$$

The domestic price of non exporters $p_d(z)$ is not directly affected by a nominal depreciation of the exchange rate (it does not depend on e). Indeed, $p_d/\hat{P}_d$ is homogeneous of degree zero on w and $\hat{P}_d$; if wages and the aggregate domestic price move at the same rate, the domestic price of non exporters will raise at this rate too.

Substituting optimal quantities in the profit function gives:

$$\pi_n = \hat{P}_d \left(\alpha\rho\, z^{\frac{1-\alpha}{\alpha}} \, \frac{\hat{P}_d}{w}\right)^{\frac{\alpha(\rho-1)}{1-\alpha\rho}} \left(\alpha\rho\, z^{\frac{1-\alpha}{\alpha}} \, \frac{\hat{P}_d}{w}\right)^{\frac{\alpha}{1-\alpha\rho}} - z^{\frac{\alpha-1}{\alpha}} \left(\alpha\rho\, z^{\frac{1-\alpha}{\alpha}} \, \frac{\hat{P}_d}{w}\right)^{\frac{1}{1-\alpha\rho}} w - wh_p =$$

$$\hat{P}_d^{\frac{1}{1-\alpha\rho}} \left(\frac{\alpha\rho\, z^{\frac{1-\alpha}{\alpha}}}{w}\right)^{\frac{\alpha\rho}{1-\alpha\rho}} (1-\alpha\rho) - wh_p.$$

In the case of **unconstrained exporters**, we have $\eta = 0$. Combining the optimal conditions, the optimal domestic price becomes

$$\boxed{p_d = \frac{e\,p_\$}{\rho}.}$$

Since domestic sales and exports are jointly produced, their prices have to equalize after correcting for trade costs, implicit in $p_\$$, and domestic markups. Domestic quantities set by exporters equalize marginal costs also to marginal income in the domestic market. Notice that the domestic price set by unconstrained exporters does not depend on their productivities.

Equilibrium domestic sales are then given by the demand function

$$q_d = \left(\frac{\rho \hat{P}_d}{ep_\$}\right)^{\frac{1}{1-\rho}},$$

independent of firm's specific productivity. From the marginal condition for exports

$$q_x = \left(\frac{\alpha ep_\$}{w}\right)^{\frac{\alpha}{1-\alpha}} z - q_d.$$

Notice that

$$z > z_{\text{mín}} = \alpha^{\frac{\alpha}{\alpha-1}} \left(\frac{w}{ep_\$}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{\rho \hat{P}_d}{ep_\$}\right)^{\frac{1}{1-\rho}}$$

is required to $q_x \geq 0$. $z_{\text{mín}}$ depends negatively on the foreign price $p_\$$ and is homogeneous of degree zero on prices $\hat{P}_d$, $ep_\$$ and w.

Unconstrained exporters' profits are obtained after substituting the optimal conditions in the profit function:

$$\pi_u = \frac{ep_\$}{\rho}\left(\frac{\rho \hat{P}_d}{ep_\$}\right)^{\frac{1}{1-\rho}} + ep_\$ \left[\left(\frac{\alpha ep_\$}{w}\right)^{\frac{\alpha}{1-\alpha}} z - \left(\frac{\rho \hat{P}_d}{ep_\$}\right)^{\frac{1}{1-\rho}}\right] - z^{\frac{\alpha-1}{\alpha}} \left(\left(\frac{\alpha ep_\$}{w}\right)^{\frac{\alpha}{1-\alpha}} z\right)^{\frac{1}{\alpha}} w - ef_\$ - wh_p.$$

After some algebra, this becomes

$$\pi_u(z) = \underbrace{\frac{1-\rho}{\rho}\,(\rho \hat{P}_d)^{\frac{1}{1-\rho}}\,(ep_\$)^{\frac{\rho}{\rho-1}}}_{(p_d - ep_\$)q_d} + \underbrace{(1-\alpha)\left(\frac{\alpha}{w}\right)^{\frac{\alpha}{1-\alpha}} z (ep_\$)^{\frac{1}{1-\alpha}}}_{ep_\$(q_d+q_x) - w\cdot z^{\frac{\alpha-1}{\alpha}}(q_d+q_x)^{\frac{1}{\alpha}}} - ef_\$ - wh_p.$$

As explained above, profiting from their local market power, unconstrained exporters set a domestic price larger than the foreign price. The first term in the previous equation corresponds to the gain of selling q_d in the domestic market instead of producing and exporting it. The second term corresponds to the optimal profits of producing and exporting $q_d + q_x$. The first derivative of π_u wrt $p_\$$ is positive for $z \geq z_{\text{mín}}$.

Exit Firms that cannot obtain positive profits from selling domestically or selling in both markets will exit. This is given by the condition $\pi_n < 0, \pi_u < 0$. Equalizing the profit function for domestic firms to zero, it will give the exit productivity cut-off z^* for non exporters

$$\boxed{z^* = \left(\frac{w}{\hat{P}_d}\right)^{\frac{1}{(1-\alpha)\rho}} \left(\frac{h_p}{1-\alpha\rho}\right)^{\frac{1-\alpha\rho}{(1-\alpha)\rho}} (\alpha\rho)^{\frac{\alpha}{\alpha-1}}.} \tag{EC}$$

The exit cutoff z^* of non exporters does not depend on the export conditions $p_x, \bar{q}_x$ faced by the marginal firm. As we will see later, being a non exporter will depend on them. Non exporters will produce if $z \geq z^*$; as we will show later, this conditions is sufficient but not necessary.

Given the productivity cutoff z^* obtained for non exporters, another expression can be obtained for the non exporter profit. The exit condition gives

$$wh_p = (1-\alpha\rho)\,(z^*)^{\frac{(1-\alpha)\rho}{1-\alpha\rho}} \left(\frac{\alpha\rho}{w}\right)^{\frac{\alpha\rho}{1-\alpha\rho}} \hat{P}_d^{\frac{1}{1-\alpha\rho}}$$

Substituting on the profit function, non exporting firms' profits are

$$\pi_n(z) = (1-\alpha\rho)\left(\frac{\alpha\rho\, z^{\frac{1-\alpha}{\alpha}}}{w}\right)^{\frac{\alpha\rho}{1-\alpha\rho}} \left(\hat{P}_d\right)^{\frac{1}{1-\alpha\rho}} - (1-\alpha\rho)\,(z^*)^{\frac{(1-\alpha)\rho}{1-\alpha\rho}} \left(\frac{\alpha\rho}{w}\right)^{\frac{\alpha\rho}{1-\alpha\rho}} \hat{P}_d^{\frac{1}{1-\alpha\rho}} =$$

$$(1-\alpha\rho)\left(\frac{\alpha\rho}{w}\right)^{\frac{\alpha\rho}{1-\alpha\rho}} \left(\hat{P}_d\right)^{\frac{1}{1-\alpha\rho}} \left[z^{\frac{(1-\alpha)\rho}{1-\alpha\rho}} - z^{*\frac{(1-\alpha)\rho}{1-\alpha\rho}}\right] = wh_p\left[\left(\frac{z}{z^*}\right)^{\frac{(1-\alpha)\rho}{1-\alpha\rho}} - 1\right].$$

In addition, a firm to exit should also find that optimal profits from exporting and selling domestically are negative, i.e. $\pi_u < 0$. From the analysis above for non exporters, we know that domestic firms with productivity $z < z^*$ will never produce for the domestic market only. However, if the export price $p_\$$ is large enough, they may be interested in producing for both the domestic and foreign market simultaneously. This will be the case if profits are large enough to cover both the production and export fixed cost. Consequently, for firms with $z < z^*$, the zero profit condition for exporters z^*_{zp} is

$$\boxed{z^*_{zp} = \frac{1}{(1-\alpha)}\left(wh_p + ef_\$ - \frac{1-\rho}{\rho}\,(\rho\hat{P}_d)^{\frac{1}{1-\rho}}\,(ep_\$)^{\frac{\rho}{\rho-1}}\right)\left(\frac{\alpha}{w}\right)^{\frac{\alpha}{\alpha-1}} (ep_\$)^{\frac{1}{\alpha-1}}\,.} \tag{XC_1}$$

z^*_{zp} is increasing for small values of $p_\$$, and there is a maximum at

$$ep_\$ = \left(\frac{\rho\,(wh_p + ef_\$)}{(1-\alpha\rho)}\left(\rho\hat{P}_d\right)^{\frac{1}{\rho-1}}\right)^{\frac{\rho-1}{\rho}}.$$

This corresponds to productivity level

$$z = \left(\frac{w}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} \left(\frac{\rho\,(wh_p + ef_\$)}{1-\alpha\rho}\right)^{\frac{\rho\alpha-1}{\rho(\alpha-1)}} \left(\rho\hat{P}_d\right)^{\frac{1}{\rho(\alpha-1)}}.$$

This productivity level is greater than z^* if and only if

$$ef_{\$} > wh_p \left[\left(\frac{w}{\alpha}\right)^{\frac{2\rho\alpha}{1-\alpha\rho}} - 1 \right].$$

If we impose such condition z^*_{zp} intersects z^* from above. The export price at which a firm with productivity $z*$ obtains not only zero profits as a domestic producer but also zero profits as an exporter is denoted $ep^*_{\$}$.

Non exporting firms have to obtain positive profits from selling only domestically, and they should exceed those that would have obtained selling in both markets ($\pi_n > 0, \pi_n > \pi_u$). The first condition is given by $z > z^*$.

The second condition implies that the difference in net revenues between being an exporter and being a domestic firm should not be large enough to pay for the export fixed costs:

$$\hat{P}_d^{\frac{1}{1-\alpha\rho}} \left(\frac{\alpha\rho\, z^{\frac{1-\alpha}{\alpha}}}{w} \right)^{\frac{\alpha\rho}{1-\alpha\rho}} (1-\alpha\rho) >$$

$$\frac{1-\rho}{\rho} \, (\rho\hat{P}_d)^{\frac{1}{1-\rho}} \, (ep_{\$})^{\frac{\rho}{\rho-1}} + (1-\alpha) \left(\frac{\alpha z^{\frac{1-\alpha}{\alpha}}}{w} \right)^{\frac{\alpha}{1-\alpha}} (ep_{\$})^{\frac{1}{1-\alpha}} - ef_{\$}.$$

This defines a cutoff region, implicitly determined by the condition

$$\boxed{\pi_u(z) = \pi_n(z).} \qquad (XC_2)$$

Let us denote this cutoff condition as z^*_u.

Unconstrained exporters Firms will become exporters if and only if profits from being exporters are positive. If they decide to export at all, they will also sell domestically. Then an export (necessary) condition is given by $\pi_u(z) > 0$.

Unconstrained firms with productivity larger than z^* will, in top of producing for the domestic market, export if and only if profits from exporting are larger than profits from producing for the domestic market only, i.e., iff $\pi_u > \pi_n$.

Notice that (XC_1) gives

$$wh_p + ef_{\$} = (1-\alpha)\, z^*_{zp} \left(\frac{w}{\alpha}\right)^{\frac{\alpha}{1-\alpha}} (ep_{\$})^{\frac{1}{1-\alpha}} + \frac{1-\rho}{\rho} \, (\rho\hat{P}_d)^{\frac{1}{1-\rho}} \, (ep_{\$})^{\frac{\rho}{\rho-1}}.$$

Substituting in the profit function of unconstrained exporters,

$$\pi_u(z) = \frac{1-\rho}{\rho} \, (\rho\hat{P}_d)^{\frac{1}{1-\rho}} \, (ep_{\$})^{\frac{\rho}{\rho-1}} + (1-\alpha) \left(\frac{\alpha}{w}\right)^{\frac{\alpha}{1-\alpha}} z (ep_{\$})^{\frac{1}{1-\alpha}} -$$

$$(1-\alpha)\, z^*_{zp} \left(\frac{w}{\alpha}\right)^{\frac{\alpha}{1-\alpha}} (ep_{\$})^{\frac{1}{1-\alpha}} - \frac{1-\rho}{\rho} \, (\rho\hat{P}_d)^{\frac{1}{1-\rho}} \, (ep_{\$})^{\frac{\rho}{\rho-1}} =$$

$$(ep_{\$})^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{w}\right)^{\frac{\alpha}{1-\alpha}} (1-\alpha) \left(z - z^*_{zp}\right)$$

For z larger but close to z^*_{zp}, the last term is close to zero and profits of an exporter will just cover both fixed costs. However, if z is much larger than z^*, profits from non exporting more than cover the fixed production costs, inducing firms to produce for the domestic market only.

The exporters are firms with of $z, p_\$$ that satisfy

$$(ep_\$)^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{w}\right)^{\frac{\alpha}{1-\alpha}} (1-\alpha)\left(z - z^*_{zp}\right) > wh_p \left[\left(\frac{z}{z^*}\right)^{\frac{(1-\alpha)\rho}{1-\alpha\rho}} - 1\right].$$

The z^*_u locus is everywhere to the right of z^*_{zp} for $z > z^*$, while both are equal for $z = z^*$. A firm with $z > z^*$, located exactly at the z^*_{zp}, would be making positive profits if produces and sells only domestically. It will not decide to have positive exports, because its profits from exporting are zero. If the export price $ep^*_\$$ increased slightly, the profits from being a domestic firm will not change, but profits as an exporter would increase. If the increment is large enough profits from exporting would exceed those from selling in the domestic market only and the firm will change its status.

The intersection point of the z^*_u and z^*_{zp} conditions corresponds to the price $ep^*_\$$ previously defined. At the point $(ep^*_\$, z^*)$ it holds $\pi_u = 0$ and $\pi_n = 0$ and hence it must also hold $\pi_u - \pi_n = 0$. Figure 3.4 shows the optimal decisions of unconstrained firms for different values of $z, p_\$$, and represents the cutoff productivities z^*, z^*_{zp} and z^*_u.

Firms with both $z < z^*$ and, for a given $p_\$$, $z < z_{zp}$ do optimally exit. They are not productive enough to produce for the domestic market only, and the export price is not large enough for covering both the fixed production and export costs. When productivity is smaller than z^*_{zp} but larger than z^*, firms optimally produce for the domestic market only. Finally, firms produce for both the domestic and foreign market when profits cover both production and export fixed costs, and exporting is more profitable than producing for the domestic market only.

Exchange rate *pass-through* and export response We are interested in the effects of a devaluation in the relative output price of exporters and output reallocation between exports and domestic sales. Such effects depend on the market equilibrium of the model.

As a consequence of equalization of the domestic price and the markup corrected export price, unconstrained exporters completely pass a nominal devaluation to the domestic price, letting their relative output price unchanged. In this sense, there will be complete exchange rate pass-through for unconstrained exporters. Unconstrained exporters profit from their market power in the domestic market to set a domestic price larger than the foreign price.

Also, they put pressure in the labor market, up to the point that wages adjust upward, proportionally to he devaluation, making non exporters also pass the devaluation through.

Notice that the unconstrained exporter's export share, $q_x/(q_x + q_d)$, not only does depend directly on the export price, but also on equilibrium wages w and aggregate consumption $\hat{P}_d$.

$$\frac{q_x}{q_x + q_d} = 1 - \left(\frac{\rho \hat{P}_d}{ep_\$}\right)^{\frac{1}{1-\rho}} \left(\frac{w}{\alpha e p_\$}\right)^{\frac{\alpha}{1-\alpha}} z^{-1}.$$

If pass-through were not complete for all goods, $\hat{P}_d$ and w will not completely follow a devaluation, implying that unconstrained firms will reduce their sales in the domestic market and

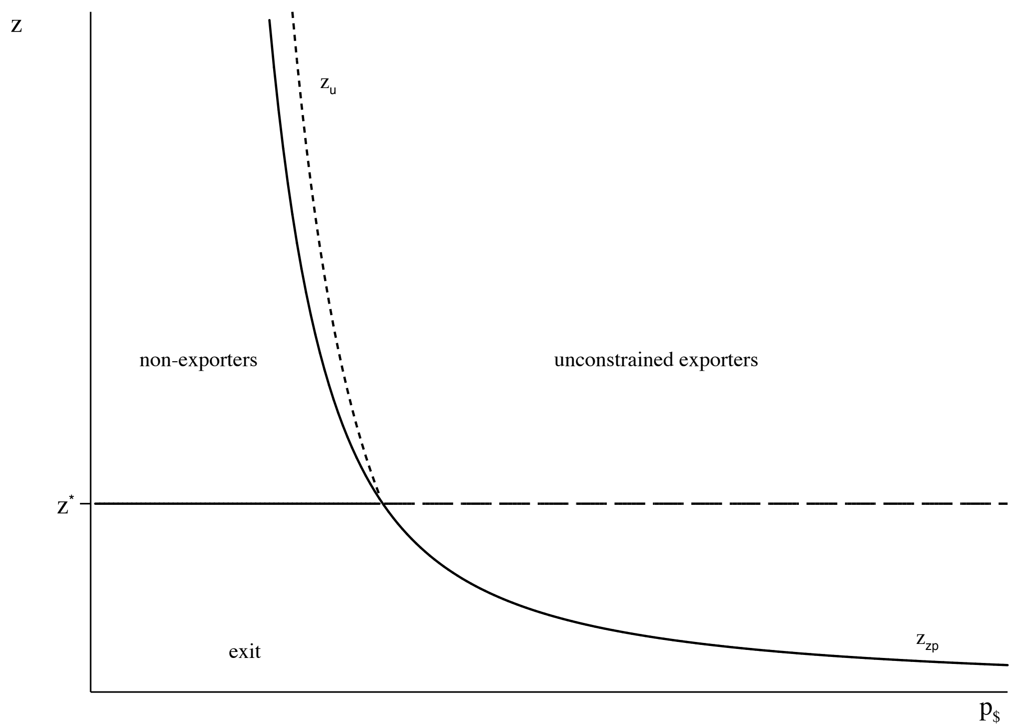


Figura 3.4: Unconstrained Regions

increase them in the foreign market, making their export shares to increase if some exporters were constrained in the foreign market. Notice that the relevant relative prices here are $ep_{\$}/\hat{P}_d$ and $ep_{\$}/w$, which could increase after a devaluation.

Our view of the wedge between domestic and export prices is based on the presence of export constraints for firms, rather than on differential markups. In what follows we analyze the general case with some constrained exporters

3.3.2. Constrained Economy

We introduce an export constraint for firms, so that a subset of firms cannot export as much as they optimally would. Some papers in the trade literature analyze heterogeneous firms trade models with constrained firms.

In Chaney (2016), export constraints are derived from the fact that domestic firms face liquidity constraints when operating in the export market. Chaney adds an extra dimension to the firm's problem, by assuming there is a random draw by firms of liquidity which can be added to domestic profits to pay for export fixed costs. Liquidity is in this sense is related to productivity, higher productivity firms being less constrained. Firms with liquidity draws under a certain cutoff threshold will not enter the export market.

Manova (2013) assumes that not only fixed export costs but also variable trade costs need to be financed in advance. This introduces the possibility that firms are constrained not only in the extensive margin (being inhibited to enter the export market because their optimal revenues cannot afford to pay the fixed entry costs), but also in the intensive margin, i.e. exporting less than their optimal decisions in absence of constraint. Manova (2013) introduces a creditor that would finance firms under a participation constraint that internalizes a probability of default and requires the firms to allocate assets as collateral. The payments (or asset collection in case of non enforcement) are part of the firm's maximization problem. When introducing a free entry condition (expected profits equal zero) the resulting productivity cutoff is higher due to financial constraints. If also variable trade costs need to be financed, also the firms desired export quantities are affected by financial constraints (intensive margin). Then a second productivity cutoff arises, and only producers with productivity above such cutoff get to export their optimal levels. Constrained firms choose to export below their unconstrained optimal level because given their productivity they would not earn sufficient revenues to repay the creditor, lowering their exports to reduce the amount of capital required for variable costs.

Constraint surface Our approach is to assume that liquidity is needed for covering both the variable trade cost and fixed export cost (i.e. $e\tau_\$ q_x + ef_\$$). We do not assume that firms use domestic nor export revenues to finance export costs. Also, we do not add an extra dimension to the firm's problem by assuming liquidity is randomly drawn, since we have already added a dimension, i.e. the the export price $p_\$$. We do not assume liquidity being randomly distributed across firms but positively related to productivity z, and so to firm size, since more productive firms produce more output and hire more inputs. Once the firm draws its pair $(z, p_\$)$ its liquidity constraint is completely determined.

To be precise, we assume that each firm is endowed with a firm specific liquidity $A(z, p_\$)$ measured in units of the domestic currency, $A(\cdot)$ having a positive derivative with respect to each of its arguments. This is not far from Chaney (2016), i.e. more productive and more profitable firms are less constrained. We want to stress the relative price $p_\$$ faced by a firm relative to others. Consequently, a firm endowed with liquidity $A(z, p_\$)$ can export up to

$$q_x(z, p_\$) \leq \bar{q}_x(z, p_\$, e) \equiv \frac{A(z, p_\$) - ef_\$}{e\tau_\$} = \frac{A(z, p_\$)/e - f_\$}{\tau_\$}.$$

If firms have liquidity enough to pay for the export fixed costs, then $\bar{q}_x > 0$. Under this assumption, if the slopes of $A(z, p_\$)$ are steep enough, low productivity (low export price) firms will be constrained but high productivity firms will not. In the following, let us assume that

$$A(z, p_\$) = Azp_\$,$$

with $A > 0$.

Unconstrained firms optimally decide to export less than $\bar{q}_x(z, p_\$)$, while constrained firms would like to export more than $\bar{q}_x(z, p_\$)$. The marginal firm that optimally chooses to produce $\bar{q}_x(z, p_\$)$ satisfies

$$\bar{q}_x(z, p_\$) = \frac{Azp_\$ - ef_\$}{e\tau_\$} = \left(\frac{\alpha e p_\$}{w}\right)^{\frac{\alpha}{1-\alpha}} z - \left(\frac{ep_\$}{\rho \hat{P}_d}\right)^{\frac{1}{\rho-1}}.$$

The export constraint increases with productivity and with the export price. Desired exports increase with productivity as well, and also increase with the export price if desired exports are positive. After some productivity/export price cutoff, the constraint should be higher than desired exports. If more productive/larger export price firms are to be constraint free, their export constraint must intersect the desired exports surface from below. Taking the derivative with respect to z, the slopes of both the export constraint and desired exports do not depend on z, only on $p_\$$. We require

$$\frac{Ap_\$}{e\tau_\$} > \left(\frac{\alpha e p_\$}{w}\right)^{\frac{\alpha}{1-\alpha}}$$

which A would satisfy for all export prices

$$p_\$ > \left[\frac{A}{e\tau_\$}\left(\frac{\alpha e}{w}\right)^{\frac{\alpha}{\alpha-1}}\right]^{\frac{1-\alpha}{2\alpha-1}}$$

as long as $\alpha < 1/2$. Also, it can be noted that the intercept of the export constraint is negative, and this ensures that there is only one crossing from below of the desired export surface.

Taking the derivative with respect to the export price we obtain

$$\frac{Az}{e\tau_\$} > \left[\frac{\alpha}{1-\alpha}\left(\frac{\alpha e p_\$}{w}\right)^{\frac{\alpha}{1-\alpha}}\frac{z}{p_\$} - \frac{1}{\rho-1}\left(\frac{ep_\$}{\rho\hat{P}_d}\right)^{\frac{1}{\rho-1}}\frac{1}{p_\$}\right].$$

This condition holds for values of productivity such that

$$z > \left[\frac{\frac{Ap_\$}{e\tau_\$} - \frac{\alpha}{1-\alpha}\left(\frac{\alpha e p_\$}{w}\right)^{\frac{\alpha}{1-\alpha}}}{-\frac{1}{\rho-1}\left(\frac{ep_\$}{\rho\hat{P}_d}\right)^{\frac{1}{\rho-1}}}\right].$$

The numerator is positive from the condition above, hence this condition always holds. The export constraint also defines a productivity-export price cutoff:

$$\boxed{z_u^* = \frac{\frac{f_\$}{\tau_\$} - \left(\frac{ep_\$}{\rho\hat{P}_d}\right)^{\frac{1}{\rho-1}}}{\frac{Ap_\$}{e\tau_\$} - \left(\frac{\alpha e p_\$}{w}\right)^{\frac{\alpha}{1-\alpha}}}.} \qquad (LU)$$

For these firms, their constrained exports will exactly equal their export constraint. Maybe abusing of notation we denote this unconstrained exporters productivity and price cutoff z_u^* (not to be confused with the unconstrained exporter cutoff of the unconstrained model). Firms with $(z, p_\$)$ above and to the right of z_u^* find their constraint above their desired export levels, hence are not constrained.

The denominator was assumed to be positive according to the condition above. To ensure the numerator is positive, the following condition on the export price being larger than a cutoff value must be met:

$$\rho\hat{P}_d\left(\frac{f_\$}{\tau_\$}\right)^{\rho-1} > ep_\$.$$

Any firm with productivity $z > z_c^*$ will face a liquidity constraint large than its optimal exports, then, it will not be liquidity constrained.

The constrained firms are to be specifically exporters, i.e .firms that find themselves with pairs $(z, p_\$)$ such that lie at the right and above of the locus z_u^*. If the locus $z_c^*(p_\$, \bar{q}_x)$ was not at the NE of the constraint $w_u^*(p_\$)$, then firms would be in the unconstrained regime studied above.

Constrained firm behavior Liquidity constrained firms find themselves able to export up to $q_x = \bar{q}_x$, which is for them smaller than the optimal level. Though will still be able to sell in the export market at price $ep_\$$, they will not set their quantity produced in order to equalize marginal revenue and cost with the "markup-corrected" $ep_\$/\rho$. Remind that constrained exporters price in the domestic market according to

$$p_d = \frac{ep_\$ - \eta}{\rho},$$

with η being strictly positive, the larger the tougher the constraint is. The firm From the optimal condition for domestic sales, q_d is implicitly determined by

$$\alpha\rho\, z^{\frac{1-\alpha}{\alpha}} \frac{\hat{P}_d}{w} q_d^{\rho-1} = (q_d + \bar{q}_x)^{\frac{1-\alpha}{\alpha}}.$$

The left-hand-side is decreasing in q_d, going to infinity when $q_d \to 0$ and zero when $q_d \to \infty$. The right-hand-side is increasing and positive. Then, an optimal solution for q_d exists and is unique. Inverting the demand function, we obtain the equilibrium price. An increase in z, as usual, raises firm's domestic sales. An increase in $\bar{q}_x$, indeed, makes firms to export more, reducing their supply in the domestic market. Indeed, total production $q_d + \bar{q}_x$ increases. Let us denote this function as $q_{dc}(z)$. Notice that $q_{dc}(z)$ is homogeneous of degree zero in P_d and w. Constrained firms will set their domestic price in their demand curve as $P_d c_d^{1-\rho} q_{dc}(z)^{\rho-1}$.

Constrained exporters profits are defined as:

$$\pi_c(z, p_\$) = P_d c_d^{1-\rho} q_{dc}(z)^\rho + ep_\$\bar{q}_x - z^{\frac{\alpha-1}{\alpha}}(q_d + \bar{q}_x)^{\frac{1}{\alpha}} w - ef_\$ - wh_p.$$

Introducing the export constraint redefines firm sorting into different subsets according to their sales destination. The separation between non exporters and exiting firms remains the same z^* locus previously defined for the unconstrained case.

With respect to exporters, the choice now comes from comparing constrained exporter profits $\pi_c(z, p_\$)$ with domestic firm profits $\pi_n(z)$. The equality

$$\pi_c(z, p_\$) = \pi_n(z) \tag{LC}$$

implicitly defines a cutoff region, which we term z_c^*.

This cutoff function, such as all the previous cutoffs, is homogeneous of degree zero on prices. However, if the constraints $\bar{q}_x$ negatively depend on the nominal exchange rate, a devaluation will move the cutoff function $z_c^*(p_\$, \bar{q}_x)$ down, making the nominal devaluation to have real effects by constraining some exporters that previously were unconstrained and by reducing exports of previously constrained exporters.

Domestic prices of exporters increase with the export price and do not respond to productivity, while domestic prices of domestic producers do not change with the export price and go down when productivity increases. Marginal costs increase with output, but exporter's profits increase with productivity and export price, i.e. in general exporters are high productivity-high export price firms. However firms close to the z_u^* locus barely obtain profits above those that they would obtain as domestic producers.

The first effect of the constraint is that some firms would exit the export market and revert to selling only domestically. These firms will be constrained because they cannot finance the fixed export cost anymore ($A(z) - ef_\$ < 0$). In this case the constraint they face is $\bar{q}_x = 0$. This corresponds to the extensive margin export constraint present in Chaney (2016) and Manova (2013). In this sense, when comparing the constrained and non constrained scenario there is a shift to the right and up of the z_u^* locus with respect to the unconstrained z_u^* locus.

There'll be a second group of firms which, that although still have larger profits as exporters than as domestic producers, obtain less profits than they would as unconstrained exporters, and given the constraint, produce less output. This is the intensive margin effect of the constraint. Manova (2013) provides an example of this.

Firm sorting is represented in Figure 3.5, which adds to Figure 3.4 a region of export constrained firms at the North-East of the (LC) locus, while the unconstrained exporters remain those at the North-East of the (LU) locus. Most productive and larger firms face the highest "level" financial constraints, but for that reason those are not binding and such firms are not constrained, in the sense that their optimal export decisions do not change with respect to the unconstrained situation.

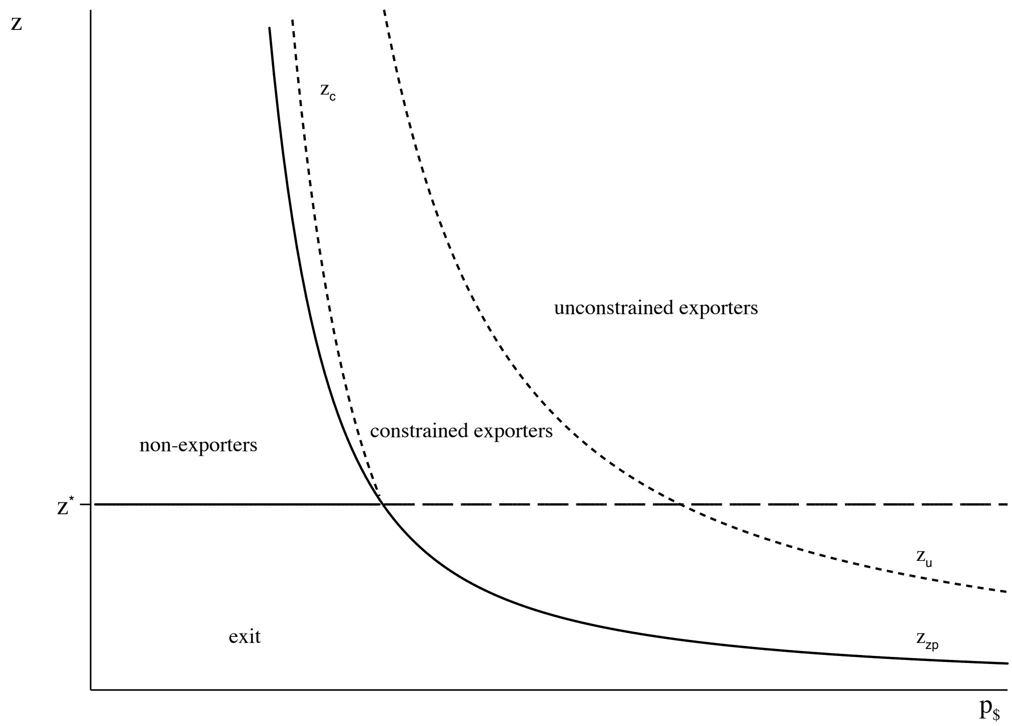


Figura 3.5: Constrained and Unconstrained Regions

Effect of a devaluation A devaluation of the local currency, an increase in e, makes liquidity more stringent and reduces $\bar{q}_x(z)$, making it more difficult for everybody to export. Notice that the same effect is to be expected from a worsening of financial conditions *per se*, i.e. a fall in A. That would indicate for a firm of given $(z, p_\$)$ more difficulty to find financial resources. This is exactly what happened in the financial crisis period that accompanied the exchange rate crisis in 2002 in Uruguay as well as in other countries.[9]

In fact, the constraint reacts more than proportionally to changes in the nominal exchange rate since (z is omitted to simplify notation)

$$\left|\frac{\dot{\bar{q}}_x}{\bar{q}_x}\right| = \frac{A(z,p_\$)/e}{A(z,p_\$)/e - f_\$}\ \frac{\dot{e}}{e} > \frac{\dot{e}}{e}.$$

A devaluation will directly affect domestic sales of constrained exporters; by reducing the export constraint $\bar{q}_x$, as argued above, it will increase q_d. At a give aggregate domestic price P_d, it will reduce the domestic price p_d, depreciating the relative output price faced by the constrained exporter. We will then observe that the export share and the relative output price of constrained exporters are negatively related.

The constraint surface shifts down. For those firms already pushed out of the export market, feasible exports are reduced and hence their status does not change, they remain domestic firms. The firms close to the z_u^* locus, however, experiment a tightening of their constraint and marginal firms are pushed out of the export market. Hence the the z_u^* locus shifts outward as a result of a devaluation.

Then the set of the constrained exporters that continue to export see tighten their export constraint. As the constraint surface shifts down, some of the high productivity firms before unconstrained start to be also constrained. In this sense, also the z_c^* locus shifts outward as a result of a devaluation. Only the subset of highest-productivity, highest-price firms will still remain unconstrained after a devaluation. This is not inconsistent with the observed fact that after a financial crisis with devaluation, the aggregate export recovery is based heavily in the response of the largest firms. This reconciles this observation of a larger aggregate export share with the fact that the export share is actually reducing after the devaluation in the cross section of exporting firms.

To develop a more formal argument, the price equation gives

$$\rho\, p_d = ep_\$ - \eta,$$

where η is the value of the export constraint. It is easy to show that $dp_d/p_d < de/e$ iff $d\eta/\eta > de/e$, i.e., constrained firms don't fully pass the devaluation to the domestic price if the value of the constraint increases more than the devaluation.

From the first order condition for exports,

$$\eta = ep_\$ - \frac{w}{\alpha z}(q_d + \bar{q}_x)^{\frac{1-\alpha}{\alpha}}.$$

[9]This is a simple way of modeling the observed correlation between the large devaluation of the Uruguayan peso in 2002 and the substantial financial constraints faced by exporters.

Let us assume that $\bar{q}_x$ decreases with a nominal devaluation. In this case, since

$$\alpha\rho\ z^{\frac{1-\alpha}{\alpha}} \frac{\hat{P}_d}{w} q_d^{\rho-1} = (q_d + \bar{q}_x)^{\frac{1-\alpha}{\alpha}}$$

for given aggregates, a decrease in $\bar{q}_x$ needs to be compensated by an increase in q_d, which reduces $q_d + \bar{q}_x$.

Even in the extreme case that wages fully follow the devaluation, it can be seen that $d\eta/\eta > de/e$ iff $q_d + \bar{q}_x$ decrease after a devaluation, which we have just shown to be the case.

3.4. Market equilibrium

3.4.1. Unconstrained Equilibrium

Let us study the behavior of an economy without financial constraints. We simplify the definition of the integration regions by redefining $z_u^*(p_\$)$ to be equal to $z_u^*(p_\$)$ for values of $z > z^*$, and equal to $z_{zp}^*(p_\$)$ for values of $z < z^*$. In this sense, the locus $z_u^*(p_\$)$ corresponds now to the pairs $(z, p_\$)$ such that exporter profits are equal to non exporter profits, if these are greater than zero, or exporter profits are equal zero when non exporter profits are negative. In both cases the condition defines the change of status into becoming an exporter, in the first case against the alternative of selling only domestically, and in the second with respect to exiting the market.

As in Figure 3.4, firms exit iff $z < \text{mín}\{z^*, z_u^*(p_\$)\}$; firms only produce for the domestic market iff $z^* < z < z_u^*(p_\$)$; finally, firms produce for the local market and export without any liquidity constraint iff $z > z_u^*(p_\$)$.

From the previous analysis, at equilibrium a firm hires flexible labor input

$$\ell_p(z) = \begin{cases} 0 & \text{for } \ z < \text{mín}\{z^*, z_u^*(p_\$)\} \\ (\alpha\rho)^{\frac{1}{1-\alpha\rho}} (z)^{\frac{\rho(1-\alpha)}{1-\alpha\rho}} \left(\frac{P_d}{w}\right)^{\frac{1}{1-\alpha\rho}} c_d^{\frac{1-\rho}{1-\alpha\rho}} & \text{for } \ z^* < z < z_u^* \\ z\ (\alpha)^{\frac{1}{1-\alpha}} \ \left(\frac{e\, p_\$}{w}\right)^{\frac{1}{1-\alpha}} & \text{for } \ z > z_u^* \end{cases}$$

sells domestically the quantity

$$q_d(z) = \begin{cases} 0 & \text{for } \ z < \text{mín}\{z^*, z_u^*(p_\$)\} \\ (z)^{\frac{1-\alpha}{1-\alpha\rho}} \left(\frac{\alpha\rho P_d}{w}\right)^{\frac{\alpha}{1-\alpha\rho}} c_d^{\frac{\alpha(1-\rho)}{1-\alpha\rho}} & \text{for } \ z^* < z < z_u^* \\ \rho^{\frac{1}{1-\rho}} \left(\frac{P_d}{e\, p_\$}\right)^{\frac{1}{1-\rho}} c_d & \text{for } \ z > z_u^* \end{cases}$$

and sets the domestic price

$$p_d(z) = \begin{cases} \text{no price} & \text{for} \quad z < \text{mín}\{z^*, z_u^*(p_\$)\} \\ \left(\frac{w}{\alpha\rho}\right)^{\frac{\alpha(1-\rho)}{1-\alpha\rho}} (z)^{\frac{(1-\alpha)(\rho-1)}{1-\alpha\rho}} \left(P_d\, c_d^{1-\rho}\right)^{\frac{1-\alpha}{1-\alpha\rho}} & \text{for} \quad z^* < z < z_u^* \\ \frac{ep_\$}{\rho} & \text{for} \quad z > z_u^* \end{cases}$$

where

$$z^* = \left(\frac{w}{P_d\, c_d^{1-\rho}}\right)^{\frac{1}{(1-\alpha)\rho}} (\alpha)^{\frac{\alpha}{\alpha-1}} \left(\frac{h_p}{1-\alpha\rho}\right)^{\frac{1-\alpha\rho}{(1-\alpha)\rho}}$$

and, for $z > z^*$, z_u implicitly solves for z in the following equation

$$\frac{1-\rho}{\rho} \left(\rho P_d c_d^{1-\rho}\right)^{\frac{1}{1-\rho}} (ep_\$)^{\frac{\rho}{\rho-1}} + (1-\alpha) \left(\frac{\alpha z^{\frac{1-\alpha}{\alpha}}}{w}\right)^{\frac{\alpha}{1-\alpha}} (ep_\$)^{\frac{1}{1-\alpha}} =$$

$$(1-\alpha\rho) \left(P_d c_d^{1-\rho}\right)^{\frac{1}{1-\alpha\rho}} \left(\frac{\alpha\rho\, z^{\frac{1-\alpha}{\alpha}}}{w}\right)^{\frac{\alpha\rho}{1-\alpha\rho}} + ef_\$ \qquad (\text{XC}_3)$$

whereas for $z < z^*$

$$z_u^* = \frac{1}{(1-\alpha)} \left(wh_p + ef_\$ - \frac{1-\rho}{\rho} (\rho \hat{P}_d)^{\frac{1}{1-\rho}} (ep_\$)^{\frac{\rho}{\rho-1}}\right) \left(\frac{w}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} (ep_\$)^{\frac{1}{\alpha-1}}. \qquad (XC_1)$$

Proposition 1 *There exists $p_\$^*$ and $p_\$^{**}$, $0 < p_\$^* < p_\$^{**}$, such that for $p_\$ < p_\$^*$ all firms do not export and for $p_\$ > p_\$^{**}$ all firms export.*

Proof. Notice that (XC_3) can be written as

$$a\, p_\$^{\frac{1}{1-\alpha}} = b - c\, p_\$^{\frac{\rho}{\rho-1}}$$

a, b and c all strictly positive.

Proposition 2 *For $p_\$^* < p_\$ < p_\$^{**}$, there exists a unique z_u that solves (XC_3)*

Let us assume that the mass of potential varieties is one and the joint cumulative distribution of productivity and export prices is $\Phi(z, p_\$)$. We assume the support for the export price $p_\$$ is the interval $[\underline{p}_\$, \bar{p}_\$]$ of positive values. The labor market clearing condition is given by

$$\int\int \ell_p(z)\ \mathrm{d}\Phi(z, p_\$) + h_p \int\int \mathrm{d}\Phi(z, p_\$) = 1,$$

where total employment has been normalized to unity. From the utility function and the associated price index we obtain:

$$c_d = \left(\int \int q_d(z)^\rho \; \mathrm{d}\Phi(z, p_\$) \right)^{\frac{1}{\rho}}$$

and

$$P_d = \left(\int \int p_d(z)^{\frac{\rho}{\rho-1}} \; \mathrm{d}\Phi(z, p_\$) \right)^{\frac{\rho-1}{\rho}} .$$

The trade balance condition determines imports residually.

Equilibrium conditions Concerning the aggregates, the equilibrium conditions for labor market clearing, aggregate consumption and the aggregate price index write as follows.

Labor market clearing condition:

$$\left(\frac{P_d c_d^{1-\rho}}{w} \right)^{\frac{1}{1-\alpha\rho}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z^*}^{z_u^*} (\alpha\rho)^{\frac{1}{1-\alpha\rho}} z^{\frac{\rho(1-\alpha)}{1-\alpha\rho}} \, d\Phi(z, p_\$) \quad +$$

$$\left(\frac{1}{w} \right)^{\frac{1}{1-\alpha}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z_u^*}^{\infty} \alpha^{\frac{1}{1-\alpha}} \; (e\, p_\$)^{\frac{1}{1-\alpha}} \, z \, d\Phi(z, p_\$) = 1 - \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z^*}^{\infty} h_p \, d\Phi(z, p_\$) \tag{LMC}$$

Aggregate consumption condition:

$$c_d^\rho = \left(\frac{P_d c_d^{1-\rho}}{w} \right)^{\frac{\alpha\rho}{1-\alpha\rho}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z^*}^{z_u^*} (\alpha\rho)^{\frac{\alpha\rho}{1-\alpha\rho}} z^{\frac{(1-\alpha)\rho}{1-\alpha\rho}} \; d\Phi(z, p_\$) \quad +$$

$$\left(P_d c_d^{1-\rho} \right)^{\frac{\rho}{1-\rho}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z_u^*}^{\infty} \left(\frac{e\, p_\$}{\rho} \right)^{\frac{\rho}{1-\rho}} \; d\Phi(z, p_\$) \tag{c_d}$$

Aggregate price index condition:

$$P_d^{\frac{\rho}{\rho-1}} = \left(\frac{1}{w} \right)^{\frac{\alpha\rho}{1-\alpha\rho}} \left(P_d \, c_d^{1-\rho} \right)^{\frac{\rho(1-\alpha)}{(1-\alpha\rho)(\rho-1)}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z^*}^{z_u^*} (\alpha\rho)^{\frac{\alpha\rho}{1-\alpha\rho}} \; (z)^{\frac{(1-\alpha)\rho}{1-\alpha\rho}} \; d\Phi(z, p_\$) \quad +$$

$$\int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z_u^*}^{\infty} \left(\frac{e p_\$}{\rho} \right)^{\frac{\rho}{\rho-1}} \; d\Phi(z, p_\$) \tag{P_d}$$

The equilibrium conditions are nonlinear functions of the aggregate equilibrium price P_d, aggregate domestic consumption c_d, and wage w. They can be factored out of integrals of functions of firms productivities, export prices, and various model parameters, and are multiplied by constants that depend on the mass of firms in each subset: exporters, non exporters and exit. When those aggregates change, firm sorting into the different groups also changes.

It can be seen that $q_d(z)$ and $\ell_p(z)$ are both homogeneous of degree zero on prices $\{P_d, w, e\}$, and the domestic prices $p_d(z)$ are homogeneous of degree one on prices $\{P_d, w, e\}$. Also, all cutoff functions are homogeneous of degree zero on prices. In absence of financial constraints, the equilibrium is defined on the set of relative prices $\{P_d/e, w/e, p_d/e\}$. Then the Walras Law applies and a devaluation has no real effect.

3.4.2. Constrained Equilibrium

As represented in Figure 3.5, firms will exit, produce for the local market only, produce for both the local and foreign market being liquidity constrained or not. Firms exit iff $z < \text{mín}\{z^*, z^*_{zp}(p_\$)\}$; firms only produce for the domestic market iff $z^* < z < z^*_c(p_\$)$; firms produce for the local market and export under an export constraint iff $z^*_c(p_\$) < z < z^*_u(p_\$, \bar{q}_x)$; finally, firms produce for the local market and export without export constraint iff $z > z^*_u(p_\$, \bar{q}_x)$. The space of export constrained firms is represented in Figure 3.5 as the region below $z^*_u(p_\$, \bar{q}_x)$ and above the constraint $z^*_c(p_\$, \bar{q}_x)$.

As before, we use the definitions to obtain optimal decisions for firms with productivity and export price $(z, p_\$)$ (see Figure 3.5). Production employment is given by

$$\ell_p(z) = \begin{cases} 0 & \text{for } z < \text{mín}\{z^*, z^*_c(p_\$)\} \\ (\alpha\rho)^{\frac{1}{1-\alpha\rho}} (z)^{\frac{\rho(1-\alpha)}{1-\alpha\rho}} \left(\frac{P_d}{w}\right)^{\frac{1}{1-\alpha\rho}} c_d^{\frac{1-\rho}{1-\alpha\rho}} & \text{for } z^* < z < z^*_c \\ z\big(\alpha\rho\big)^{\frac{1}{1-\alpha}} \left(\frac{P_d c_d^{1-\rho}}{w}\right)^{\frac{1}{1-\alpha}} q_{dc}(z)^{\frac{\rho-1}{1-\alpha}} & \text{for } z^*_c < z < z^*_u \\ z\big(\alpha\big)^{\frac{1}{1-\alpha}} \left(\frac{e\,p_\$}{w}\right)^{\frac{1}{1-\alpha}} & \text{for } z > z^*_u \end{cases}$$

Supplies in the domestic market are given by:

$$q_d(z) = \begin{cases} 0 & \text{for } z < \text{mín}\{z^*, z^*_c(p_\$)\} \\ (\alpha\rho)^{\frac{\alpha}{1-\alpha\rho}} (z)^{\frac{1-\alpha}{1-\alpha\rho}} \left(\frac{P_d}{w}\right)^{\frac{\alpha}{1-\alpha\rho}} c_d^{\frac{\alpha(1-\rho)}{1-\alpha\rho}} & \text{for } z^* < z < z^*_c \\ q_{dc}(z) & \text{for } z^*_c < z < z^*_u \\ \rho^{\frac{1}{1-\rho}} \left(\frac{P_d}{e\,p_\$}\right)^{\frac{1}{1-\rho}} c_d & \text{for } z > z^*_u \end{cases}$$

Domestic prices are set as

$$p_d(z) = \begin{cases} \text{no price} & \text{for} \quad z < \text{mín}\{z^*, z_c^*(p_\$)\} \\ \left(\frac{w}{\alpha\rho}\right)^{\frac{\alpha(1-\rho)}{1-\alpha\rho}} \ (z)^{\frac{(1-\alpha)(1-\rho)}{1-\alpha\rho}} \ \left(P_d \, c_d^{1-\rho}\right)^{\frac{1-\alpha}{1-\alpha\rho}} & \text{for} \quad z^* < z < z_c^* \\ P_d c_d^{1-\rho} q_{dc}(z)^{\rho-1} & \text{for} \quad z_c^* < z < z_u^* \\ \frac{e p_\$}{\rho} & \text{for} \quad z > z_u^*. \end{cases}$$

Constrained equilibrium conditions In the case of the constrained economy, the equilibrium conditions for labor market clearing, aggregate consumption and the aggregate price index area the following:

Labor market clearing condition:

$$\left(\frac{P_d c_d^{1-\rho}}{w}\right)^{\frac{1}{1-\alpha\rho}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z^*}^{z_c^*} (\alpha\rho)^{\frac{1}{1-\alpha\rho}} z^{\frac{\rho(1-\alpha)}{1-\alpha\rho}} \, d\Phi(z, p_\$) \quad +$$

$$\left(\frac{P_d c_d^{1-\rho}}{w}\right)^{\frac{1}{1-\alpha}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z_c^*}^{z_u^*} z \left(\alpha\rho\right)^{\frac{1}{1-\alpha}} q_{dc}(z)^{\frac{\rho-1}{1-\alpha}} \quad +$$

$$\left(\frac{1}{w}\right)^{\frac{1}{1-\alpha}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z_u^*}^{\infty} \alpha^{\frac{1}{1-\alpha}} \ (e \, p_\$)^{\frac{1}{1-\alpha}} \, z \, d\Phi(z, p_\$) = 1 - \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z^*}^{\infty} h_p \, d\Phi(z, p_\$) \tag{CLMC}$$

Aggregate consumption condition:

$$c_d^\rho = \left(\frac{P_d c_d^{1-\rho}}{w}\right)^{\frac{\alpha\rho}{1-\alpha\rho}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z^*}^{z_c^*} (\alpha\rho)^{\frac{\alpha\rho}{1-\alpha\rho}} z^{\frac{(1-\alpha)\rho}{1-\alpha\rho}} \, d\Phi(z, p_\$) \quad +$$

$$\int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z_c^*}^{z_u^*} q_{dc}^\rho \, d\Phi(z, p_\$) \quad + \left(P_d c_d^{1-\rho}\right)^{\frac{\rho}{1-\rho}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z_u^*}^{\infty} \left(\frac{e \, p_\$}{\rho}\right)^{\frac{\rho}{1-\rho}} \, d\Phi(z, p_\$) \tag{Cc$_d$}$$

Aggregate price index condition:

$$P_d^{\frac{\rho}{\rho-1}} = \left(\frac{1}{w}\right)^{\frac{\alpha\rho}{1-\alpha\rho}} \ \left(P_d \, c_d^{1-\rho}\right)^{\frac{\rho(1-\alpha)}{(1-\alpha\rho)(\rho-1)}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z^*}^{z_c^*} (\alpha\rho)^{\frac{\alpha\rho}{1-\alpha\rho}} \ (z)^{\frac{(1-\alpha)\rho}{1-\alpha\rho}} \ d\Phi(z, p_\$) \quad +$$

$$\left(P_d \, c_d^{1-\rho}\right)^{\frac{\rho}{(\rho-1)}} \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z_c^*}^{z_u^*} q_{dc}^\rho \, d\Phi(z, p_\$) \quad + \int_{\underline{p}_\$}^{\bar{p}_\$} \int_{z_u^*}^{\infty} \left(\frac{e p_\$}{\rho}\right)^{\frac{\rho}{\rho-1}} \, d\Phi(z, p_\$) \tag{CP$_d$}$$

Devaluation effect In our framework, indeed, a devaluation tightens the constraints $\bar{q}_x$ for everybody. As a consequence, firms that were previously constrained will face a tougher constraint, exporting less, increasing their production for the domestic market and letting their domestic prices increase less than the nominal devaluation.

Moreover, some firms that were not previously constrained, will become constrained, increasing their sales in the domestic market and passing the devaluation through only partially. The behavior of constrained exporters will make the aggregate domestic price P_d to increase less than the foreign prices, making the real exchange rate to depreciate.

When financial constrains become tougher for everybody, constrained exporters are forced to reduce their exports and their production, freeing labor and pushing the wage rate down. At the same time, they increase their offer in the domestic market pushing domestic prices down. The reduction in the wage rate and in domestic prices pushed non exporters to reduce their prices too, which reinforces the negative effect on the domestic price. Notice that the domestic prices of unconstrained exporters remain unchanged, since it is determined by foreign prices.

The domestic price reduction of constrained exporters and non exporters induce exporters to reallocate production towards the foreign market, increasing their exports, which partially compensates the reduction of constrained exports. As a consequence, constrained exporters see their real exchange rate depreciate at the time their exports contract, while unconstrained exporters increase their exports without changing their real exchange rate. The correlation between the real exchange rate and exports at the firm level is then negative.

3.5. Numerical evaluation

Though analytically closed form solutions are not available, the model can be evaluated by simulation of its results, solving numerically for the equilibrium given values of parameters α, ρ, $f_\$$, h_p, A, e, and τ. What follows is an exploratory display of the model mechanics that just intends to show how results are produced.

We construct a database of hypothetical firms for a grid of values of z and $p_\$$, and compute the optimal firm responses satisfying the constraints of the model. In practice, we generate a square grid of 400 points for both variables at intervals of 0.1 units, for z between 0.5 and 1, and for $p_\$$ between 1.05 and 2. Excluding the lower interval for $p_\$$ helps to avoid negative optimal exports or a positive slope of the zero profit price-productivity locus z^*_{zp}, as discussed in section 3.1. We also restrict to a region in which firms will not enter production as exporters, *i.e.* we work for values of $(z, p_\$)$ for which $z^*_{zp} > z^*$. We are assuming a simple uniform distribution, just weighting the mass of productivities and export prices by the inverse of the number of firms.

We obtain firm's optimal supply choices according to the equations discussed before computing profits, given $(z, p_\$)$, in each of the alternative scenarios, i.e. exporting or selling only in the domestic market. However profits depend on model aggregate equilibrium values of P_d, w and c_d.

Equilibrium conditions can be expressed as functions of equilibrium values as

$$\left(\frac{P_d c_d^{1-\rho}}{w}\right)^{\frac{1}{1-\alpha\rho}} V_1 + \left(\frac{1}{w}\right)^{\frac{1}{1-\alpha}} V_2 = 1 - V_3 \qquad \text{(LMC)}$$

$$c_d^{\rho} = \left(\frac{P_d c_d^{1-\rho}}{w}\right)^{\frac{\alpha\rho}{1-\alpha\rho}} V_4 + \left(P_d c_d^{1-\rho}\right)^{\frac{\rho}{1-\rho}} V_5 \tag{c$_d$}$$

$$P_d^{\frac{\rho}{\rho-1}} = \left(\frac{1}{w}\right)^{\frac{\alpha\rho}{1-\alpha\rho}} \left(P_d\, c_d^{1-\rho}\right)^{\frac{\rho(1-\alpha)}{(1-\alpha\rho)(\rho-1)}} V_4 + V_5 \tag{P$_d$}$$

where $V_1 - V_6$ are the integrals of functions of z, $p_{\$}$ and model parameters over the subsets of firms defined by price-productivity cutoffs as discussed in section 4.1. In the case of the constrained model extra terms are added to account for constrained exporting firms. We could in principle solve this nonlinear system of equations in P_d, w and c_d for unique solutions given V_1 to V_6, but these are in turn functions of P_d, w and c_d.

To obtain such solutions we start by a set of candidate initial values of aggregates $\widetilde{P}_d$, $\widetilde{w}$ and $\widetilde{c}_d$ and compute the model equilibrium. Instead of obtaining an explicit functional expression for price-productivity cutoffs we simply sort firms in each subset by comparing their profits in each of the alternatives. We setup the nonlinear equation system and obtain solutions for the three unknowns. The procedure is based on Newton's method and evaluates the sum of squares of the equilibrium conditions obtained by computing firms' optimal choices, substituting candidate values into their maximization problems.

Then we reestimate the model, feeding the computed solutions for P_d, w and c_d as the initial aggregates and repeating the procedure, generating iteratively candidate solutions until convergence is achieved.[10]. After very few realizations the results settle and remain unchanged from then on.

3.5.1. Unconstrained model simulation

Once the equilibrium is computed, we recover a set of descriptive statistics of the model economy. First we check the effect of a change in the exchange rate on some key dimensions of the economy for the unconstrained case. We are interested in entry into the export market and output reallocation between domestic sales and exports. Our estimation is based on the parameter configuration shown in Table 2, which are kept constant through all equilibrium computations:

Table 2
Parameter configuration
Unconstrained model simulation

α	0,33
ρ	0,70
h_p	0,41
$f_{\$}$	0,53

[10]The procedure is coded in command `nl` in Stata.

The mechanics of the exercise consist of giving values to the exogenous exchange rate e, and computing the equilibrium in each case. We report the resulting model aggregates P_d, w and c_d on Table 3.

Table 3
Equilibrium aggregates
Unconstrained model simulation

e	0,130	0,140	0,150
c_d	0,125	0,111	0,069
P_d	0,149	0,154	0,167
w	0,043	0,047	0,049

It can be observed that the aggregate quantity index of domestic production shrinks. New entering exporters equalize the price of their exports and domestic sales to marginal costs, and that implies that their domestic production is selling at higher prices, which is tracked by the evolution of the aggregate domestic price index P_d. The overall increase in output (the sum of domestic sales and exports) is matched by an increase in labor demand that drives up the wage.

This is in turn matched by changes in firm sorting into exit, non exporters and exporters. In table 4 we report changes in distribution firm status as the exchange rate is increasing, given the chosen parameter configuration. An increase of the exchange rate makes the exporting option available to previously non exporting firms –provided they can afford fixed export costs that also increase with the exchange rate. With a larger exchange rate we observe an increase in the fraction of exporting firms, and also a slight increase in firms that do do not make positive profits and exit given their z, $p_{\$}$ and environment parameters. The pressure put on the wage in equilibrium pushes some marginal firms out of the market.

Table 4
Distribution of firms by export status
Unconstrained model simulation

e	0,13	0,14	0,15
Exit	20 %	20 %	30 %
Non exporters	46 %	44 %	31 %
Exporters	34 %	36 %	40 %

The we turn to prices and exchange rate *pass-through*. We compute a simple index for the exchange rate matching the nominal changes displayed in tables 3 and 4, whereas for domestic prices we use the composite index form the model equilibrium conditions. To track changes of the export prices, we compute an index using the same weighting as we do for the domestic prices, raising prices to the $\rho/(\rho-1)$ power and integrating over the mass of exporting firms. Then we obtain a relative export price indicator in the aggregate by simply dividing the exchange rate by the aggregated domestic price index, and set it to 1 at the initial exchange rate. Finally we compute the individual ratio to obtain the following:

Table 5 Prices and exchange rate *pass-through* Unconstrained model simulation			
e	100,0	107,7	115,4
P_x	100,0	103,8	104,8
P_d	100,0	103,7	112,1
Aggregate rel price P_x/P_d	100,0	107,9	107,8
Firm rel price exporters P_x/P_d	100,0	100,0	100,0

As the exchange rate increases, the export price also increases, though less than the exchange rate. This is due to composition effects, since changes of firm status into exporters brings in firms that have lower productivity and export prices. By construction of the unconstrained model, the relative export price of exporters p_x/p_d is not changing with the exchange rate. We can see however in the aggregate the relative export price go up. The domestic prices go up, and this corresponds to the fact that domestic output is shrinking as shown by index c_d. In sum, *pass-through* is substantial, but not complete. We see the aggregate relative price increase, but less than the exchange rate.

Finally we also computed the optimal exports and domestic production of exporters, to obtain the export share. The average by exchange rate is shown in Table 6.

Table 6 Export shares $q_x/(q_x + q_d)$ Unconstrained model simulation			
e	0,13	0,14	0,15
N of exporters	135	143	158
Export share	0,989	0,991	0,994

We observe increases in the average export share when the exchange rate increases. Marginal revenue equalization with marginal cost of joint export and domestic output indicates that exports will increase and domestic output will reduce for exporters. For a firm changing form non exporter to exporter, it would also mean a reduction of domestic output.

3.5.2. Constrained model simulation

In what follows we also present a simulation of results of the constrained model. The iterative procedure works in the same manner as in the unconstrained model. The set of base parameters is the same as in the unconstrained model simulation, with the exception of the liquidity constraint parameter A which is added, and the variable trade cost parameter τ which was previously implicit in the export price and is now made explicit. For this exercise we work with $A = 0{,}09$ and $\tau = 0{,}38$.

The important difference between the constrained and the unconstrained model simulation is that the former involves the determination of the domestic output for the constrained exporting firm, q_{dc}. There is not an explicit expression for this quantity given z, $p_\$$ and A. Hence in each step of the simulation we must obtain, for each firm, the solution of the nonlinear equation in q_d that defines the firm's constrained domestic output. That is finding the q_d that solves:

$$\alpha\rho\, z^{\frac{1-\alpha}{\alpha}} \frac{\hat{P}_d}{w} q_d^{\rho-1} = (q_d + \bar{q}_x)^{\frac{1-\alpha}{\alpha}}.$$

We do this by making the algorithm stop at every iteration at each $(z, p_\$)$ point to obtain numerically the firm's constrained domestic output and use it to calculate firm profits in each alternative status. There are four conditions now for firms: exit, non exporter, and constrained and unconstrained exporter.

We start from the equilibrium conditions and aggregates obtained under the export constraint, which we show in Table 7. Each column of this table is to be compared with corresponding column in Table 3, which comes from an economy that has the same parameter configuration, but in which none of the firms are export constrained.

Table 7
Equilibrium aggregates
Constrained model simulation

e	0,130	0,140	0,150
c_d	0,222	0,246	0,294
P_d	0,156	0,150	0,131
w	0,042	0,040	0,034

Initially, in the constrained economy we observe more domestic production, expressed in larger c_d, at a smaller domestic price P_d. We see also a smaller wage level. For the larger exchange rate values we observe that larger domestic production than in the unconstrained economy is not matched by domestic price increases. This has to do with the fact that constrained firms (with respect to the unconstrained situation) export less than is optimal and produce more domestic output. The domestic output aggregate picks the contribution of domestic firms that remain as such, exporters that cease to be exporters and become domestic firms, and unconstrained exporters that remain as constrained.exporters.

With respect to firm status, there is less exit in the constrained economy, while we see much more non exporters, and the smaller group of exporters contains now the subsets of the constrained and unconstrained. The frequencies are shown in table 8.

Table 8
Distribution of firms by export status
Constrained model simulation

e	0,13	0,14	0,15
Exit	10,0 %	10,0 %	5,0 %
Non exporters	65,5 %	66,8 %	74,3 %
Const exporters	8,3 %	15,8 %	20,0 %
Unconst exporters	16,3 %	7,5 %	0,8 %

With respect to prices and *pass-through*, we can observe that with respect to the unconstrained economy, under constraint the export price indicator is higher (not reported), as reflecting exit from the export market of the marginal exporters. In Table 9 we report the changes in prices as the exchange rate increases.

Table 9
Prices and exchange rate *pass-through*
Constrained model simulation

e	100,0	107,7	115,4
P_x	100,0	103,8	104,8
P_d	100,0	103,7	112,1
Aggregate rel price P_x/P_d	100,0	107,9	107,8
Firm rel price exporters P_x/P_d	100,0	100,0	100,0

In turn, selection leads to a smaller number of exporters but with larger average export shares, as shown in table 10.

Table 10
Export shares $q_x/(q_x + q_d)$
Constrained model simulation

e	0,13	0,14	0,15
N of exporters	98	93	83
Export share	0,980	0,986	0,993

To analyze the effect of an exchange rate increase in an economy populated by constrained firms, we compare horizontally the columns of tables 7 to 10. If the exchange rate grows in a constrained economy, domestic production expands and this brings down the domestic price index in a remarkable magnitude. This is the opposite of the unconstrained economy. Wages would go down, while in the unconstrained case they would go up. The fraction of non exporting firms would increase, and while constrained exporters would increase, the total number of exporters would go down as increasingly less firms remain as unconstrained exporters less. Selection would push dollar export prices higher than it would be the case in a unconstrained case. Though exporters are limited in the quantities they can sell, the prices they receive go up after the devaluation. The relative export price amplifies the exchange rate increase.

3.6. Conclusions

This paper introduces a variant of the class of the heterogeneous firms trade models in which firms differ along two dimensions, the export price they receive for their exports and their productivity. Firms are price takers in the export market, while monopolistically compete in the domestic market. Instead of the constant marginal cost that is frequently assumed, a concave technology is introduced. Small economy assumptions allow to solve the model in relative isolation of determination of foreign economies output and the exchange rate, that remains exogenous to firms in the home economy. Profit maximization by firms determines domestic prices as well as domestic and export supply. The objective is to study the impact of exchange rate fluctuations in firm entry and exit in the export markets and in output allocation between domestic sales and exports. If firms take their decisions without further constraints, the relative export price would remain unchanged in the face of a positive exchange rate shock, while there would be entry in the export markets and an increase of the export share.

A contribution of the model is to introduce an export constraint faced by firms, which is modeled as arising from their need to finance in advance fixed and variable trade costs. The constraint depend on firm's productivity and the exchange arte they face, and also on the exchange rate. An exchange rate increase makes exporting profitable to firms with smaller productivity and export price levels. However the export constraint tightens as trade costs increase and foreign assets shrink. Some firms exporting may exit the export market, while constrained firms reduce their exported output and increase their domestic supply. This introduces a wedge between the export price and the domestic price. Though the domestic price rises, passthrough is not complete. This may help to account for a degree of negative correlation observed at the firm level between the export share and the relative export price.

Though analytical closed form solutions were not available, the model lends itself to easy numerical computation of its constrained and unconstrained equilibria, and simulations confirm the mentioned properties with respect to relative prices and output allocation.

Another property of the model that would be interesting to explore further is that the unconstrained exporting firms are those with high productivity and prices: they would hire more, have larger revenues, etc. This would match the observed fact that export recovery after devaluations is based heavily on the contribution of a relatively low number of large firms. Also, changing assumptions on the distribution of firms's productivities and prices would probably produce interesting qualitative variations in the model results.

References

[1] Melitz, M. J., (2003), The impact of trade on intra-industry reallocations and aggregate industry productivity, *Econometrica* 71 (6): 1695-1725.

[2] Berman, N., P. Martin and T. Mayer, (2012), How do different exporters react to exchange rate changes?, *Quarterly Journal of Economics* 127(1):437-449.

[3] Berman, N., A. Berthou and J. Héricourt, (2015), Export dynamics and sales at home, *Journal of International Economics* 96 298-310

[4] Hopenhayn, H., (1992), Entry, exit, and firm dynamics in long run equilibrium, *Econometrica* 60, 1127-1150.

[5] Chaney, T. (2016), Liquidity constrained exporters, *Journal of Economic Dynamics & Control* 72 141-154.

[6] Demidova S., and A. Rodríguez-Clare, (2009), Trade policy under firm-level heterogeneity in a small economy, *Journal of International Economics* 78 100-112.

[7] Demidova S., and A. Rodríguez-Clare, (2013), The simple analytics of the Melitz model in a small economy, *Journal of International Economics* 90 (2013) 266-272.

[8] Manova , K, (2013), Credit constraints, heterogeneous firms, and international trade, *The Review of Economic Studies*, 80, p.711-744

4 Export performance measurement, productivity and prices

Resumen

Se realiza la estimación econométrica de ecuaciones para indicadores a nivel de empresa de desempeño exportador (condición de exportador y participación de exportaciones en ventas totales) en el contexto de grandes cambio en los precios relativos, en función de variables del entorno y características estructurales de las empresas. La medición del desempeño y en particular medidas de productividad total de los factores dependen de la elección de período base para obtener valores a precios constantes en que se basan las estimaciones de coeficientes de la función de producción. La deflación separada de exportaciones y ventas domésticas es particularmente sensible a la evolución divergente de los precios domésticos y los de las exportaciones. Para la condición de exportador se estima un probit dinámico. La condición en el período pasado es altamente significativa lo que se interpreta como evidencia de la importancia de los costes fijos en la decisión de exportar. En la ecuación el precio de exportación relativo tiene un signo negativo pero no estadísticamente significativo. Para la intensidad exportadora se usa el procedimiento de estimación logit fraccional, y se obtiene un efecto del precio relativo de exportación significativo y negativo, aún controlando por el precio de las exportaciones.

Abstract

We undertake the econometric estimation of equations for firm-level export performance indicators (exporting status and export share) in the context of large relative prices changes, as a function of environment variables and structural firm characteristics. Performance measurement and particularly total factor productivity measures depend on base prices choices to obtain production function coefficients estimates. Productivity is measured in terms of base year constant price values. Separate deflation of exports and domestic sales is particularly sensitive to divergent evolution of domestic and export prices. For the export status a dynemic probit is estimated. Last period status is highly significant which is related to the relevance of fixed costs in exporting decisions. The relative export price is not significant in the equation. In the export share equation a fractional logit model is estimated. The relative price has a significant and negative impact, even after controlling for export prices.

4.1. Introduction

In this paper we analyze firm level export response to exchange rate fluctuations, in terms of enter or exit from the export market, price decisions and output allocation choices with respect to exports and domestically sold output. We estimate changes in the export status and the export share as they are affected by exchange rate *pass-through* to domestic prices and the resulting relative export price.

We attempt to control by the effect of using constant revenue output measures. Whether firm or sector prices are used, the construction of revenues at base year prices entails a choice of base period. From the measurement point of view, exchange rate fluctuations will impact constant price revenues through changes in valuation of exports with respect to domestic sales, and capital and intermediate input measures through their imported components. In general, this will have consequences in micro TFP estimation, exporter-non exporter productivity differentials and other firm-level export performance measures. We illustrate our argument using firm level data from manufacturing in Uruguay in 1997-2005, when sweeping real exchange rate movements accompanied a financial crisis.

Section 2 presents our framework to describe firm behavior and the generation of firm performance and productivity indicators. Section 3 describes the data. In section 4 we present the main facts with respect to relative prices, export response and input decisions. Section 5 undertakes total factor productivity assessment and the estimation of firm performance measures. Section 6 concludes.

4.2. Firm behavior and export performance

Assume firms can sell their output domestically or in the export market. Take Q_{dit} and Q_{xit} to be domestic and export quantities of firm i in period t. If we take ℓ_{it} to be a composite input given by

$$\ell_{it} = L_{it}^{\alpha_L} K_{it}^{\alpha_K} M_{it}^{\alpha_M}$$

where L_{it}, K_{it} and M_{it} are labor, capital and materials, then firms produce a single product at time t under

$$Q_{dit} + Q_{xit} = \ell_{it}^{\beta} \omega_{it}^{1-\beta}$$

Firms have some degree of market power in the domestic market, so they face a negatively sloped domestic demand schedule written as:

$$Q_{dit} = P_{dit}^{\frac{1}{\rho-1}}.$$

where P_{dit} is the domestic price and $\rho \in (0,1)$. In turn, the exporter is a price taker in the international market, and sells at P_{xit}.[1] The export price P_{xit} is the product of the export dollar price $P_{\$it}$ times the exchange rate e_t.

[1] Many developing economies concentrate their exports in a relatively non diversified set of commodities based on agricultural comparative advantage. In our view, this describes adequately the sample of firms from Uruguay in 1997-2005 which will be analyzed below.

Instead of physical output Q_{dit} or Q_{xit}, we only observe data on revenues. For the exporting firm revenue is given by $R_{it} = P_{\$it}e_t Q_{xit} + P_{dit}Q_{dit}$. A domestic firm optimally chooses $Q_{xit} = 0$. Firm's revenues are then given by

$$R_{it} = Q_{dit}^{\rho} + Q_{xit}P_{\$it}e_t.$$

We assume that some firms operate under an export constraint. At least a subset of firms are able to export less than they optimally would. Constrained firms would export up to $\overline{Q}_{xit}$. In general, the constrained export level would depend on the firm's price and productivity, i.e. $\overline{Q}_{xit} = \overline{Q}_{xit}(P_{\$it}, \omega_{it}, e_t,).$[2]

Omitting index i to simplify, firms seek to maximize

$$\max_{Q_{dt},Q_{xt}} Q_{dt}^{\rho} + Q_{xt}P_{\$t}e_t - \omega^{\frac{\beta-1}{\beta}}(Q_{dt} + Q_{xt})^{\frac{1}{\beta}}w$$

subject to $Q_{xt} \leq \overline{Q}_{xt}$, where w is the composite input price. The first order conditions are

$$P_{dt} = \underbrace{\frac{1}{\rho}}_{\text{markup}} \underbrace{\frac{\omega^{\frac{\beta-1}{\beta}}}{\beta} (Q_{dt} + \overline{Q}_{xt})^{\frac{1-\beta}{\beta}} w}_{\text{marginal production cost}}$$

and

$$P_{\$t}e_t = \frac{\omega^{\frac{\beta-1}{\beta}}}{\beta} (Q_{dt} + \overline{Q}_{xt})^{\frac{1-\beta}{\beta}} w + \eta,$$

where η is the Kuhn-Tucker multiplier associated to the constraint. In general it would hold

$$P_{dt} = \frac{P_{\$t}e_t - \eta}{\rho}$$

whereas for an unconstrained exporting firm it would hold $P_{dt} = P_{\$t}e_t/\rho$, i.e. exchange rate changes would translate fully into domestic price changes.

First order conditions give the firm's optimal supplies. Domestic firms optimally decide to have $Q_{xit} = 0$, and their optimal domestic supply is characterized by

$$Q_{dt}(\omega) = \left(\beta\rho\frac{\omega^{\frac{1-\beta}{\beta}}}{w}\right)^{\frac{\beta}{1-\beta\rho}}.$$

For unconstrained exporters, equilibrium domestic sales are given by the demand function:

$$Q_{dt} = \left(\frac{P_{\$t}e_t}{\rho}\right)^{\frac{1}{\rho-1}},$$

[2] We analyze in Casacuberta and Licandro (2017) the operation of this constraint and derive it from the firms needs to finance export fixed and variable costs.

and they do not depend of firm's productivity. Supply of exports is derived from the marginal condition:

$$Q_{xt} = \left(\frac{\beta P_{\$t} e_t}{w} \right)^{\frac{\beta}{1-\beta}} \omega - Q_{dt}.$$

Unconstrained exporters would respond to changes in their export prices by adjusting their exports in the same direction of the price change. As they adjust their domestic prices to changes observed in their export prices, they locate themselves in their product demand curve and adjust output accordingly. Domestic output would react in the opposite direction to that of the export price change. In figure 4.1 the unconstrained exporter behavior is described.

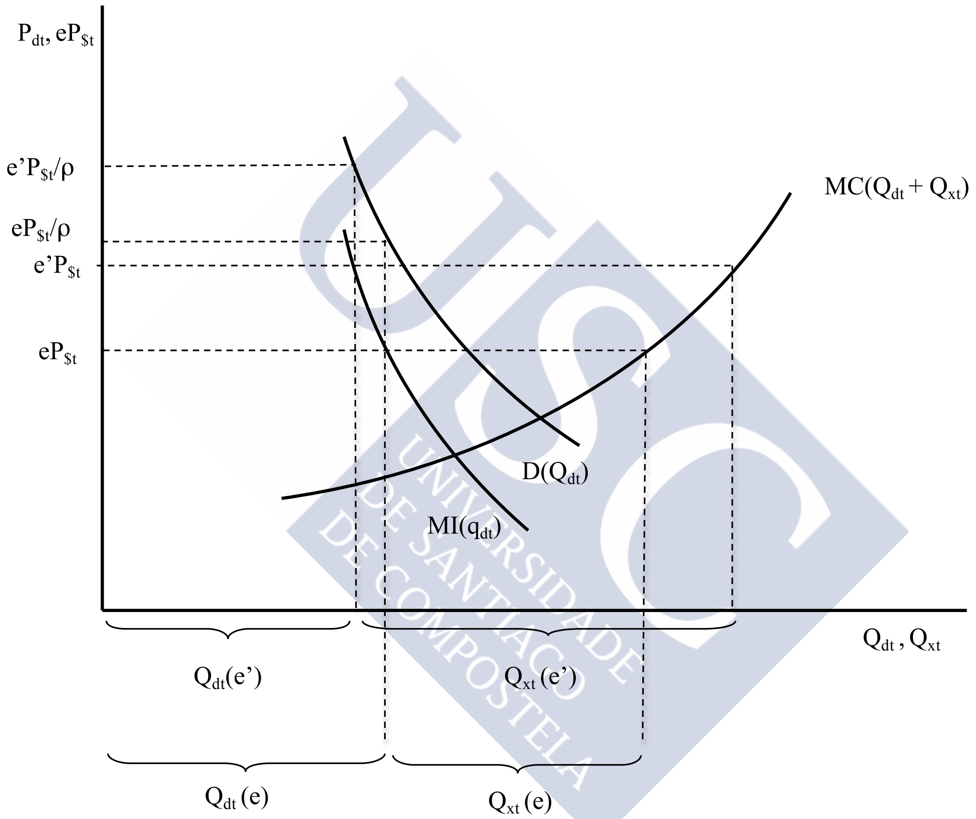


Figura 4.1: Unconstrained exporters decisions

For an exchange rate e, the exporting firm sets the total quantity so that marginal cost of $Q_{dt} + \overline{Q}_{xt}$ equals $P_{\$t}e$, marginal income in the export market. The firm also finds Q_{dt} so that marginal cost of domestic output also equals $P_{\$t}e$. The demand curve determines that such quantity is to be sold domestically at a $P_{\$t}e/\rho$ price. If the exchange rate went up to e', total quantity produced would increase, domestic output would shrink and exports would grow.

Constrained exporters can export only up to $\overline{Q}_{xt}$, but can optimally choose Q_{dt} equalizing marginal revenue of the extra unit of domestic output to the joint marginal cost of the sum $Q_{dt} + \overline{Q}_{xt}$. A constrained exporter would choose the domestic quantity Q_{dt} that solves:

$$\beta \rho Q_{dt}^{\rho-1} \frac{\omega^{\frac{1-\beta}{\beta}}}{w} = (Q_{dt} + \overline{Q}_{xt})^{\frac{1-\beta}{\beta}}$$

They would compare their profits as a constrained exporter and as a domestic producer, and choose the condition that yields higher (positive) profits . If profits are negative in both cases the firm would exit.

Constrained exporters would export less and sell domestically more then they would in absence of export constraints. This implies that their domestic price will be less than it would have been being unconstrained. Figure 4.2 compares the unconstrained and the constrained exporters choices.

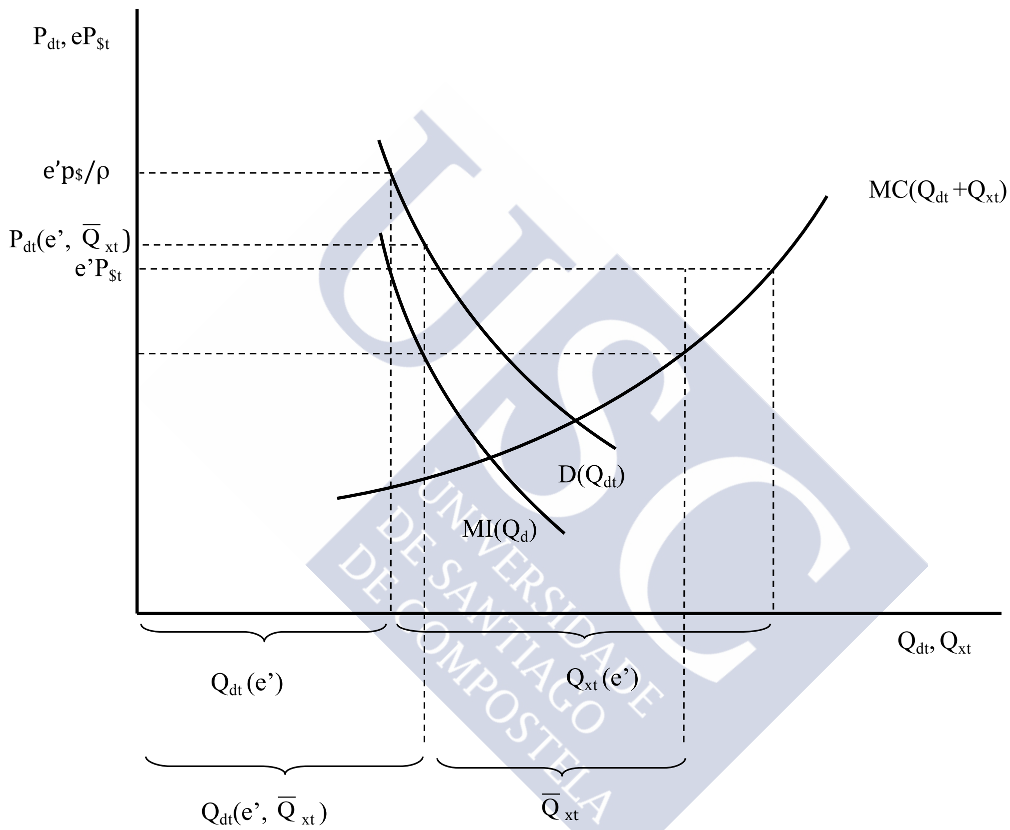


Figura 4.2: Constrained and unconstrained exporters decisions

While an unconstrained exporter facing an exchange rate e' would sell $Q_{xt}(e')$ units in the export market and $Q_{dt}(e')$ domestically, a constrained exporter could only sell $\overline{Q}_{xt} < Q_{xt}$. The firm has to set Q_{dt} so as to equalize marginal revenue of Q_{dt} with marginal cost of $Q_{dt} + \overline{Q}_x$. Its exports are less and its domestic output more than that of an unconstrained exporter. Notice that these $\overline{Q}_{xt}$ would be sold at the full $P_{\$t}e'$ price, the same as an unconstrained exporter would.

When facing an exchange rate increase, a constrained exporter's reaction depends on how the export constraint changes. At a given constraint, their exporting incomes would increase, hence firms with a lower productivity would now find profitable to enter the export market. At the same time, the constraint itself may become tougher if a devaluation for instance reduces the firm's access to financing. Assume the constraint goes down, then a larger domestic output would be required to equalize the marginal domestic cost to the sum of domestic production and constrained exports. Domestic and export prices, in this case, would move in opposite directions. An example is shown inFigure 4.3.

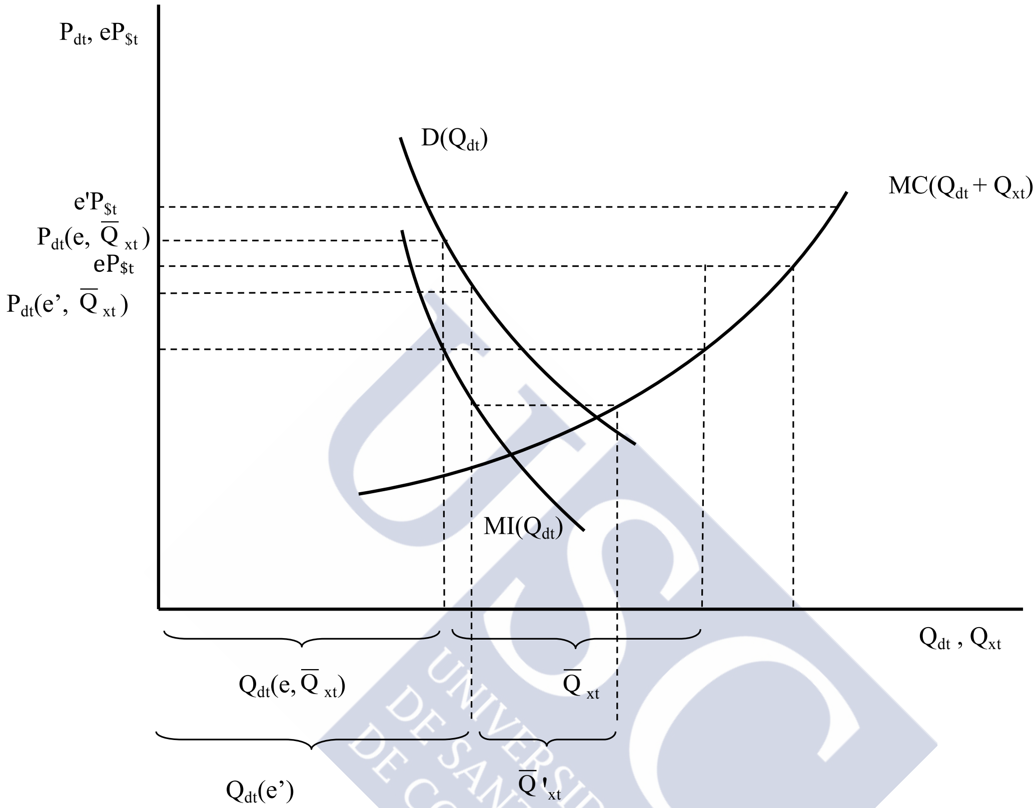


Figura 4.3: Constrained exporters decisions

If the exchange rate moved up from e to e', the constrained exporter would be selling $\overline{Q}_{xt}$. Assume the exchange rate goes up to e'. If at the same time the export constraint tightens to $\overline{Q}'_{xt}$, exported output will reduce accordingly, while domestic output expands. It can be noticed however that those exports carry an export price $e'\overline{P}_{\$t}$ larger than before the exchange rate shock.

This has consequences also in output allocation, *i.e.* the intensive margin of export response of firms as measured by the export share $Q_{xt}/(Q_{xt} + Q_{dt})$. The unconstrained exporters export share is given by

$$\frac{Q_{xt}}{(Q_{xt} + Q_{dt})} = 1 - \left(\frac{1}{\rho}\right)^{\frac{1}{\rho-1}} \left(\frac{\beta}{w}\right)^{\frac{\beta}{\beta-1}} \frac{(P_{\$it}e_t)^{\frac{1+\beta\rho}{(1-\rho)(\beta-1)}}}{\omega}$$

This implies the export share would increase in the face of an exchange rate increase for unconstrained exporters. Our firm behavior assumptions imply an exchange rate shock would not alter the ratio between P_{xt} and P_{dt}, which will be constant and equal to ρ. In the case of a constrained exporter, if the constraint reduced with the exchange rate increase, the export share could in principle be reduced when the exchange rate goes up.

4.3. Prices and firm-level productivity measurement

Firm-level quantity and price data are not generally available in firm level datasets used to study a wide range of firm behaviour and performance issues, many of them involving estimating micro level total factor productivity. Some papers such as Foster, Haltiwanger and Syverson (2008) had indeed access to firm level price and quantity data, for sectors in which production is considerably homogeneous and undifferentiated, and obtained quantity total factor productivity estimations (TFPQ) which could be compared to the usual revenue-based measures (TFPR). However physical quantity total factor productivity estimates have a meaningful interpretation only within the context of narrowly defined sectors or markets. In fact, only expressing all magnitudes in terms of base period monetary units gives the possibility to actually compare TFP measures between firms producing different products in different sectors. To do so, TFP estimations have to be constructed using revenues measured at some base year constant prices.

Deflators are usually defined at a sector level. Firm-level prices are generally unavailable, and sector level deflators are used, which affects the estimation of production function coefficients. For instance Klette and Griliches (1997) and De Loecker (2011) propose estimation procedures that seek to control for demand shocks affecting such estimates, while taking care of deviations between firm and sector price.

In order to recover productivity estimates that are comparable across firms and time, data should be expressed in terms of constant prices. Let's denote 0 our base period. Let us assume that, to obtain constant price measures, we can use firm specific price indexes for their domestic and export output (we abstract here from differences between sector level and firm level deflators).

Both for domestic and export sales, such firm-level price indexes are defined as the ratio of each year's price over the base year price, respectively $PI^x_{it} = P_{xit}/P_{xi0}$ and $PI^d_{it} = P_{dit}/P_{di0}$. The export price PI^x_{it} depends on the export price in dollars and on the exchange rate.

We deflate separately domestic and export sales, and get, using the bars for revenues at constant period 0 prices (again omitting firm subindex i):

$$\overline{R}_t = \frac{PM_{xt}Q_{xt}}{PI^x_t} + \frac{P_{dt}Q_{dt}}{PI^d_t} = P_{x0}Q_{xt} + P_{d0}Q_{dt} = \frac{P_{xt}Q_{xt} + PI_tQ_{dit}}{PI_{it}}$$

Separate deflation of exports and domestic sales is equivalent to using a Paasche type firm level price index PI_t. Such Paasche-type weighting refers only to the aggregation of prices of exports and domestic goods. In practice firms sell in the export market and domestically many different goods and P_{xt} and P_{dt} will also be aggregate indexes. A Paasche index is the inverse of a weighted average of the inverses of simple price indexes (for exported and domestically sold output, respectively), where the weights are the current period firm's export/sales ratios $\delta_t = P_{xt}Q_{xt}/(P_{xt}Q_{xt} + P_{dt}Q_{dt})$ and domestic sales/total sales ratio $(1 - \delta_t)$.[3]

[3]In Appendix A we recall the definition.

Firms' intermediate inputs can be split in its domestically purchased (M_{dt}) and imported (M_{mt}) components. Assume, as in Halpern et al. (2015), that the intermediate good M_{it} is an aggregation of the domestic and the imported varieties:

$$M_t = \left(M_{dt}^{\frac{\gamma-1}{\gamma}} + M_{mt}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}$$

Cost minimization of total intermediate input quantity M_{it} gives that relative demand for imported and domestic inputs depends on the ratio of their prices:

$$\frac{M_{mt}}{M_{dt}} = \left(\frac{P_{mt}^M}{P_{dt}^M} \right)^{-\gamma}$$

using P_{dt}^M and P_{mt}^M for domestically purchased and imported materials prices. The same deflation procedure as for revenues is applied to intermediate inputs M_{it}. Omitting the i subindex, it would give:

$$\overline{M}_t = \frac{P_{dt}^M M_{dt}}{PI_{dt}^M} + \frac{P_{mt}^M M_{mt}}{PI_{mt}^M}$$

where PI_{dt}^M and PI_{mt}^M are domestically purchased and imported materials price indexes, respectively.

Generally, micro level total factor productivity measures are obtained by estimating the production function coefficients. We abstract here from the conditions required for coefficients of the production function to be correctly identified, and assume the researcher did somehow obtain a set of coefficients $\widehat{\alpha^*}_h = \widehat{\beta\alpha_h}$ for $h = K, L, M$, controlling for endogeneity and demand shocks if any.[4] These in turn would be plugged into some variant of the revenue expression to obtain:

$$\widehat{\omega}_t = \overline{r}_t - \widehat{\alpha^*}_l l_t - \widehat{\alpha^*}_k k_t - \widehat{\alpha^*}_m \overline{m}_t - controls \tag{4.1}$$

where lowercases indicate logarithms. Labor input l_{it} will be measured in physical terms as the number of employees or hours worked. The capital flow of services indicator k_{it} will be proportional to the depreciated capital stock calculated by the perpetual inventory method using price constant investment data. Constant price revenues $\overline{r}_{it}$ and material inputs $\overline{m}_{it}$ are computed as defined above.

Constant price revenues and its export share weights will reflect the evolution of domestic and export prices. Measured constant price material inputs will also change as the relative imported and domestic prices change, and when the share of each origin changes in total input purchases. Finally, the production function coefficient estimates may also change when the base period is changed.[5]

[4] See for instance Olley and Pakes (1997), Levinsohn and Petrin (2003) and DeLoecker (2011).

[5] We do not analyze how changes in the exchange rate affect purchases of domestic and imported capital goods, which affect measurement of capital services through all the equipment service span.

The Paasche aggregation we are using implies that we can interpret constant price revenues and material input purchases, respectively, as measured at base period prices, *i.e.* $Q_{xt}P_{x1} + Q_{dt}P_{d1}$ and $M_{mt}P^M_{m1} + M_{dt}P^M_{d1}$. So the base year choice influences decisively the weight of the exported output and imported inputs in their respective totals.

When TFP is measured at constant prices of a high exchange rate base year, firms that export a large portion of their output will appear as more productive. In the same manner, firms that import a large fraction of their inputs will appear as less productive, since material inputs will explain a larger proportion of their output leaving a smaller residual to be interpreted as productivity. The result in terms of export performance indicators depends on the evolution of prices, export physical quantities, and domestic and imported input use of the exporting firms.

Our empirical exercise consists of evaluating the impact of base year choice in a series of standard firm level indicators using a panel of Uruguayan manufacturing firms for a period of particularly sharp exchange rate movements. To do so we calculate the constant price firm variables for the T different possible base years, and compare the production function estimates, TFP micro indicators and exporter productivity premiums in each case.

4.4. Data

We use annual firm level manufacturing data from the Encuesta Anual de Actividad Económica (Economic Activity Survey) 1997-2005 of the National Statistics Institute of Uruguay (INE). The panel includes consistent annual data on sales (domestic and export), production, labor (number of workers), capital and intermediate inputs (such as electricity, fuel, water and materials).[6]

As mentioned before, in order to control for the differential effect of output prices, a firm specific deflator was created by dividing domestic sales and exports by separate two-digit ISIC sectorial domestic and export price indexes.

As noted before, firms in most cases produce more than one product. Our dataset includes domestic sales and export value data by product class for each year. Though we do not have data on firm-specific prices, we can separately deflate sales, for each product, by its sector price index, both for exports and domestic sales.

In this sense, both PI^0_{dt} and PI^0_{xt} -sector level domestic and export price indexes at base year 0 prices, are in turn Paasche-type indexes, since for the m products of the firm, each of them belonging to ISIC sector j, real revenues R^0_t -revenues of year t at year 0 price- can be written as:

$$R^0_t = \sum_m \frac{R_{xmjt}}{PI^0_{xjt}} + \sum_m \frac{R_{dmjt}}{PI^0_{djt}}.$$

[6]Some of the variables however have missing values for year 2002, due to information for that year being collected in 2003, using a less detailed questionnaire for some variables. In particular, data on separate domestic sales and export sales value are absent in 2002, which will require some specific treatment to be detailed below.

To deflate domestic and export sales value we use respectively the dollar price index of exporters (multiplied by a U$S dollar value index), and the sector domestic produce price index, both published by Uruguay‘s Central Bank (BCU), defined at a two-digit ISIC aggregation level, with the exception of a few narrowly defined products with a large share in export revenue.[7]

Separately deflating exports and domestic sales (Paasche aggregation) instead of using an aggregate sector index for total revenues has advantages. Consider sectors where exporters and non exporters coexist. The usual 4-digit ISIC price index of the National Statistic Institue of Uruguay (INE), would implicitly weight domestic and export revenues, generating aggregate sector indexes in which each firm would contribute with its own export/sales ratio. If, in a context of real exchange rate increases, we deflate with the resulting sector output price index, exporters would have their prices undervalued (the sector export/sales average ratio is less than the firm ratio) and there output overvalued, while non exporters would have their prices overvalued and their output undervalued.

So when measuring constant price revenues, in the cross section exporters would appear as too productive, and non exporters as relatively less productive. Firms differ in their exports/sales ratios, hence using the average price index would disproportionately reduce the constant price output value of firms that do not export and increase it for firms that export a larger than average fraction of their output.

For intermediate inputs, firm-specific prices were also computed by deflating separately purchases of imported and domestic materials using domestic and imported sector price indexes.

Many firms import inputs directly, others buy imported inputs in domestic markets. Our survey includes information on firms' value of domestic and imported materials purchases by product and sector of origin.[8] Analogously as with revenues (omitting the firm subindex), we deflate separately for the k inputs, each of them belonging to ISIC sector j, used by the firm:

$$\overline{M}_t = \sum_k \frac{P^M_{dkjt} M_{dkjt}}{PI^M_{djt}} + \sum_k \frac{P^M_{mkjt} M_{mkjt}}{PI^M_{mjt}}$$

Domestic inputs and domestically purchased foreign inputs are aggregated, and the imported data include only material inputs directly imported by the firm.

Capital services k_t at period t were computed for a firm entering the sample at period t_0, with $t \geq t_0$, according to

$$k_t = k_{t_0} \left(1-\delta\right)^{t-t_0} + \sum_{s=t_0+1}^{t} \frac{i_s}{p_{Is}} \left(1-\delta\right)^{s-t_0-1},$$

[7]We do not account for different firms in the same sector exporting to different countries and thus exposed to different real exchange rates. Firm specific prices of non-exporters are by construction equal to the domestic sectorial price, the same for all non-exporters in the same sector.

[8]Such data are available for all sample years except 2002.

where k_{t_0} is the initial accounting value of capital measured at 1997 prices, δ is the depreciation rate,[9] i_t is investment at current prices, and p_{It} is the investment deflator (produced by the Central Bank of Uruguay with base year 1997).[10] Imported and domestically purchased investment figures were also deflated separately.

To study the impact of base year choice we construct all the 9 versions of the data base, each at constant prices of each available base year from 1997 to 2005. Our original base year was 1997, since many of the indexes were originally set using 1997 base prices. While between 1997 and 2005 large relative price changes were observed, the 1997 real exchange rate is not far from the 1997-2005 average.

To generate multiple databases, each at different base year prices, we change the base year by dividing the whole column of sector index values by the base 1997 price index corresponding to the new base year. This is not conceptually a base change, which would have involved a recalculation of the reference goods basket, but an approximation by variation chaining. This will be the procedure to deflate our revenues and material input micro data. For capital, we've recalculated price indexes for investment in machinery and equipment, taking the domestic and imported components and deflating each one separately. Then we run the perpetual inventory calculation to obtain service flow estimates for each base year.

4.5. Descriptive overview

In what follows we describe output prices in the domestic and the export market, and changes in exporting performance of firms in the extensive and intensive margin. The we turn to imported and domestic input purchase decisions and their relative prices.

4.5.1. Relative output prices

Large exchange rate movements affected the performance of manufacturing firms. In 1999, Uruguay faced a 66 % depreciation of the Brazilian Real against the dollar; then, following the December 2001 financial Argentinian crisis, there was a 100 % devaluation of the Uruguayan peso against the dollar in 2002, at the time that the Argentinian peso devaluated around 400 %. The nominal movements in the exchange rate of the U$ against these three currencies during our sample period are much larger than those of the decade before.

We show in Table 1 the time series of averages of sector level price indexes, in which each sector weighs proportionally to the number of firms from that 4 digit ISIC class present in the sample.[11]

[9] δ was defined based on values used by the U.S. Bureau of Economic Analysis (BEA).

[10] Our index only considers machinery and equipment.

[11] We do not provide different base years since they give parallel average time series paths. Export prices and relative prices are computed using a smaller set of observations, i.e. they are averages of firm specific indexes for those firms that exported in each year. Since we do not have 2002 sales data, we use the 2003 sales weights to compute firm level price data for that year. Year 1997 corresponds to the base year adopted by the INE and BCU to measure its price indexes.

Table 1
Relative export price p_x/p_d, export and domestic prices, export dollar price and dollar value
(indexes base year = 1997)

Year	Relative price	Export price	Domestic price	Export dollar price	Dollar value
1997	100,0	100,0	100,0	100,0	100,0
1998	99,4	108,6	109,9	98,0	110,9
1999	91,6	102,6	113,0	85,5	120,1
2000	93,0	106,9	115,9	83,4	128,1
2001	106,4	115,1	109,9	81,6	141,0
2002	137,0	173,3	132,4	77,1	224,8
2003	149,8	242,3	172,0	81,2	298,3
2004	149,4	263,7	189,5	86,9	303,5
2005	131,4	230,1	188,5	88,9	258,8

Source: INE database

Export dollar prices actually deteriorate until 2002, and only partially recover afterwards. If firms had some degree of market power in the export market, the changes in dollar prices would be of the opposite sign in the face of an exchange rate increase, hence this can be seen as indirect evidence in favor of our view of exporting firms as price takers in the export market. The dollar value shows the sharp increase described before. Hence the export price (the product of both) also increases. Though we see the domestic price accelerate after 2002, it never quite catches up with the change in the export prices.[12]

To summarize the effect of exchange rate shocks on domestic and export prices, we compute the (sector level) **relative export price** as the ratio between the export and domestic price indexes IP_x/IP_d, that equals 100 in the chosen base year. The average relative price deteriorates up to 1999, and then evolves upward with a large spike in 2002, and grows until 2005 when it shows a small decrease. The extreme case of overvaluation is 1999, and of undervaluation, 2003.

There is significant variation between sectors in the evolution of this indicator.[13] In some sectors -as Clothing, or Leather and Shoe- the domestic price is changing very little, hence the relative price closely follows the evolution of export price. Other sectors show the domestic price increasing with a lag in response to the initial devaluation of the real and the posterior devaluation of the $ against the U$, partially compensated by the devaluation of the A$ against the U$. There is also variation in the speed at which domestic prices accompany the export price changes (*pass-through*), but in general, at least within our sample period, domestic prices only partially catch up with export prices.

4.5.2. Export growth

We examine first export response by firms when exchange rate experiences large fluctuations. Dollar exports actually decreased between 1998 and 2001, and started to grow in 2002, to

[12]When considering only firms that export (not reported), the evolution of domestic prices is similar.
[13]See figure 4.5 in Appendix B.

reach double digit rates in 2002-2005. When we look at manufacturing exports by destination, they follow closely the evolution of bilateral exchange rates. Exports to Brazil plunge in 1999 coincidently with devaluation of the Real, while exports to Argentina fall sharply in 2002. The post 2002 recovery is mild, except with respect to exports to the USA and Canada. Figure 4.4 displays the evolution of manufacturing exports by destination.[14]

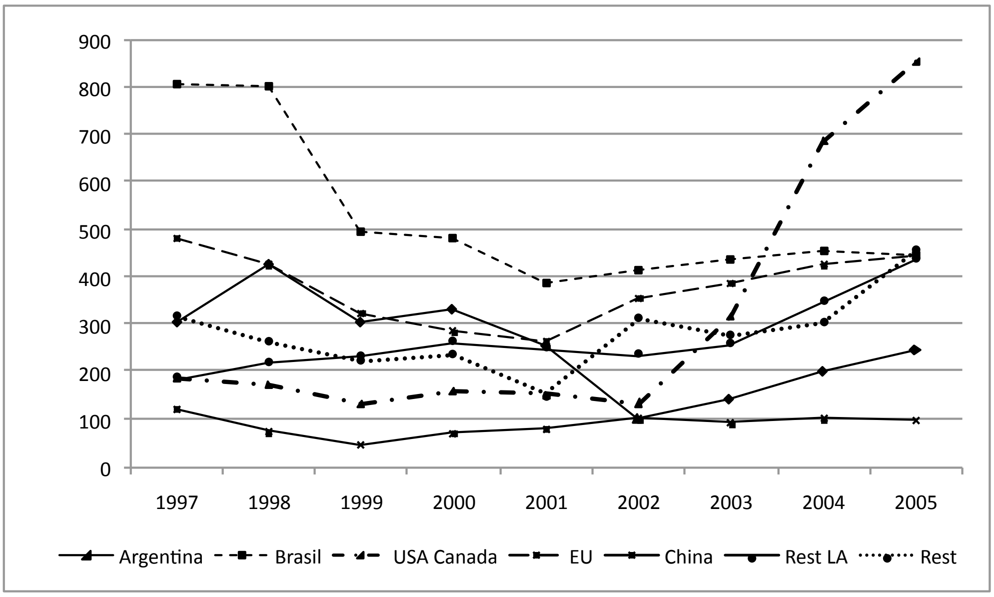


Figura 4.4: Uruguay: manufacturing exports by destination

We want to track how our firm data relate to the aggregate evolution. We look into export growth in those firms that were already exporting, i.e. the intensive margin, and also present evidence on entry/exit by firms in the export market, i.e. the extensive margin. First we analyze firm level export growth. To avoid the effects of firms entering of exiting the sample, in Table 2 we present indicators of the distribution of firm level export growth rates, both with respect to the last period and two periods before.[15]

[14]Data pubished by the Central Bank of Uruguay.
[15]We do not have firm export data for 2002 and cannot distinguish firm exports by destination.

Table 2						
Firm level constant price export growth rates						
Yearly rates						
Period	98/97	99/98	00/99	01/00	04/03	05/04
Median	-0,06	-0,13	-0,03	-0,14	0,15	0,12
p95	2,26	2,17	1,78	1,18	2,64	3,43
Biannual rates						
Period	99/97	01/99	03/01	05/03		
Median	-0,20	-0,12	-0,24	0,35		
p95	2,77	1,66	2,61	5,10		
% of firms with g>0						
Period	99/97	01/99	03/01	05/03		
	0,37	0,39	0,36	0,67		

Source: INE database. At 1997 constant prices.

When comparing two distributions in different moments, it is usual to compare means, generally performing some variation of a t-test. This assumes that distributions do not differ in other characteristics, which may not be the case, i.e. mass can change in other parts of the distribution other than the central location. In this case we believe that changes in the median growth rate, and in the fraction of firms experiencing positive export growth give sufficient indication of a shift rightward of the whole distribution.[16] Firms have been increasing their exports by 2004, and though 2003 exports are for a large fraction of firms smaller in constant terms than they were in 2001, for some of them they might be larger than the even lower 2002 exports.

4.5.3. Export share

Secondly, we analyze changes in the export share. Our description of firm behavior indicated that the export share would evolve differently in the face of an exchange rate increase for firms facing constraints in their exports and not. For the aggregate sample, there is an increase in the share of exports in exporting firms revenues.[17] However this is not so evident for the distribution of individual firm's export shares.[18] Though individual export shares fall in 2001 with respect to 2000, and fall in 2003 with respect to 2001, changes are not as marked as in the aggregate.

We emphasize the distribution of export share changes rather than observing the statistics of firms year by year which are more sensitive to composition effects.[19] Table 3 presents indicators of the distribution of differences in firm level export shares.

[16]The shift in the distribution can be also graphically appreciated in Figure 4.6 in the Appendix.
[17]see table A1 in the Appendix.
[18]See in Appendix Table A2 median firm level export shares.
[19]See Table A1 in the Appendix with our sample statistics of the export share by year.

Table 3
Firm level export share differences

Yearly						
Period	98/97	99/98	00/99	01/00	04/03	05/04
mean	-0,01	-0,01	-0,01	-0,02	-0,02	-0,02
p1	-0,58	-0,51	-0,63	-0,40	-0,67	-0,56
p5	-0,16	-0,20	-0,26	-0,22	-0,24	-0,26
p50	0,00	-0,01	0,00	0,00	0,00	0,00
p95	0,17	0,19	0,18	0,13	0,15	0,14
p99	0,40	0,47	0,27	0,38	0,30	0,28
iqr	0,07	0,08	0,07	0,08	0,08	0,08

Biannual				
Period	99/97	01/99	03/01	05/03
mean	-0,02	-0,02	0,00	-0,02
p1	-0,56	-0,57	-1,00	-0,67
p5	-0,29	-0,30	-0,35	-0,31
p50	-0,01	0,00	0,00	0,00
p95	0,22	0,17	0,29	0,19
p99	0,40	0,34	0,51	0,31
iqr	0,09	0,10	0,12	0,10

% of firms with d>0				
Period	99/97	01/99	03/01	05/03
	0,46	0,39	0,38	0,56

Source: INE database. Current prices.

There is no obvious general rightward shift in the distribution of export share changes, in particular we do not find significant shifts in the median which is always close to zero. Neither does the dispersion as measured by the interquartile range change significantly. We can recover however the increase of the fraction of firms with gains in their export share in 2005 with respect to 2003 as indicative of some response to the relative price changes after 2002. Figure 4.7 in the appendix plots the histograms of export share growth with respect to two years before, conditional on having exports larger than zero in the initial period.

Meanwhile, the exchange rate appreciation in 1998-2000 is not associated on average with an overall decrease in the export share of firms. It might have been the case that shrinking exports were matched by decreasing domestic sales in the context of the recession after 1999, hence the export shares did not react much. Also, for firms specialized in exporting to the Brazilian market, the devaluation of the Real in 1999 would have induced stronger exports before the 2002 changes in the exchange rate with respect to the $U\$$ dollar.

4.5.4. Export status

With respect to the extensive margin, we look at the change in the proportion of firms that export. There is a large proportion of firms with zero exports throughout all of the sample years.

The exporter condition relies in a limit that is somewhat arbitrary. Many authors regard a firm as an exporter in period t provided exports in t are larger than zero. We define as an exporter a firm obtaining form exports more than 5 % of its revenue. In Table A3 in the appendix we show the proportion of firms in the sample classified as exporters by year.[20] While the fraction of exporters increases in 2000, some firms leave the export market in 2001, and then increases in 2005 with respect to 2004. The proportion of exporters in the subset of the more stable firms (in the sample and/or in the market) is remarkably constant.

As previously analyzed in the literature (see for instance Roberts and Tybout, 1997), transitions in and out of the export market have a high degree of persistence. The literature emphasizes sunk costs as a relevant dimension of exporting decisions. In what follows we provide evidence on the rates of transition in and out the export market of firms in our sample. Table 4 shows the proportion of firms in each of the period t cells that appears in each of the two possible cells in years $t+1$ and $t+2$.[21]

Table 4
Firm transitions in the export market

One period ahead							
year t status	year $t+1$ status	97/98	98/99	99/00	00/01	03/04	04/05
No exports	No exports	93.9 %	95.0 %	94.5 %	93.6 %	94.3 %	93.4 %
	Exports	6.1 %	5.0 %	5.5 %	6.4 %	5.7 %	6.6 %
Exports	No exports	7.0 %	8.9 %	8.5 %	9.1 %	10.7 %	7.4 %
	Exports	93.0 %	91.1 %	91.5 %	90.9 %	89.3 %	92.6 %
Two periods ahead							
year t status	year $t+2$ status	97/99	99/01	01/03	03/05		
No exports	No exports	92.0 %	90.4 %	92.6 %	91.1 %		
	Exports	8.0 %	9.6 %	7.4 %	8.9 %		
Exports	No exports	9.8 %	12.7 %	15.9 %	10.5 %		
	Exports	90.2 %	87.3 %	84.1 %	89.5 %		

Source: INE database.

A remarkably large fraction of firms remain in the export market one and two years ahead regardless of the changing conditions of the exchange rate and the overall crisis scenario. The table also shows that a fraction larger than 90 % of firms not exporting do not export one or two periods ahead. We do not see a marked change in entry or exit in the export markets around the exchange rate shock years.

In summary, our data show a story based more on the export response of already exporting firms than on entry on the export markets. Even though a higher exchange rate makes the exporting activity more profitable, reducing the productivity levels at which firms can find optimal to enter the export market, if it is associated to tightening export constraints, at least for a subset of firms export response may be dampened and the export share react less fully. Also, exchange rate changes may not be perceived as long term, so it is not immediate that firms

[20] To avoid sample composition effects, we also report results for the subset of firms present through all sample years.

[21] Since 2002 micro level export data are not available in our sample, we do not present one year ahead transitions in 2001 and 2002. We do provide however 2 year ahead transitions.

will incur the expensive sunk costs associated with entry in foreign markets. With respect to firm performance measurement, we find some evidence of changes in the export shares consistent with our expected response in the face of large changes in the exchange rate.

4.5.5. Relative input prices and imported inputs

Price and exchange rates changes impact on imported input purchases. Our data reflect such impacts only partially, since our imported data only include inputs imported directly by firms. They represent however a significant fraction (around a quarter) of the value of inputs, and about half of the firms in our sample directly purchase imported material inputs in each period. Exporters in particular had special incentives to purchase import inputs directly, since in our sample years there was in place a special "temporary admission"tax regime allowing exporting firms to buy imported inputs free of tariffs.

In Table 5 we present imported and domestically purchased material inputs average firm level implicit price indexes. We also compute a firm level relative price of material inputs as the ratio of both indexes.[22]

Table 5
Domestic and imported inputs
and relative input prices
(indexes base year = 1997)

Year	Domestic Inputs	Imported Inputs	Relative Input Price
1997	100,0	100,0	100,0
1998	100,4	109,0	109,6
1999	103,7	114,6	110,8
2000	105,3	120,7	114,4
2001	120,6	133,2	110,2
2002	.	.	.
2003	153,4	271,3	185,8
2004	154,5	292,6	203,1
2005	145,3	269,5	198,2

Source: INE database.

The time series path is similar to the one displayed by the relative output price measure, though we do not see the fall in 1999. The increase in the relative price of imported material inputs starts sometime before than the relative output price acceleration. This figures show that the export inducing effect of increases in the real exchange rates might have been dampened by the effect of more expensive material imports. We define as input importers the firms that purchase some positive fraction of their materials inputs in the foreign markets and present in table 6 the fraction of firms directly importing inputs.

[22]We compute one version of such indexes for each base year.

Table 6 Percentage of firms directly purchasing imported materials - by year		
Year	All firms	Firms in all years
1997	0,46	0,55
1998	0,50	0,59
1999	0,48	0,58
2000	0,49	0,58
2001	0,46	0,57
2002	.	.
2003	0,43	0,57
2004	0,47	0,59
2005	0,45	0,57

Source: INE database.

Our data show that both the fraction of firms importing inputs and the share of imported in total materials purchases fall in 2003-2005 (but only slightly among those firms present in all the sample years). We present in Table 7 a measure of the imported input share in all materials purchases for firms directly importing some of their inputs.

Table 7 Median share of imported inputs in firm materials purchases Input importing firms - by year		
Year	All firms	Firms in all years
1997	0,56	0,58
1998	0,60	0,60
1999	0,56	0,58
2000	0,58	0,58
2001	0,60	0,60
2002	.	.
2003	0,60	0,59
2004	0,50	0,50
2005	0,52	0,52

Source: INE database.

The share of imported inputs also falls for importers after the exchange rate shock. Given our interest in the impact of prices in export performance measures, we check if the exporting firms are also generally input importers. In table 8 we display the fraction of input importers within the exporting and non exporting groups.

Table 8 Fraction of input importing firms by export status and year		
Year	Exporters	Non exporters
1997	0,69	0,29
1998	0,70	0,32
1999	0,71	0,30
2000	0,68	0,33
2001	0,68	0,31
2002	.	.
2003	0,65	0,28
2004	0,66	0,33
2005	0,66	0,28

Source: INE database.

The association between being and exporter and purchasing imported inputs is very clear throughout the sample period. The exporters however do not reduce their propensity to directly import material inputs in the last years of the sample as non exporters do.

In the next section we provide some evidence on the impacts of base year choice in micro level productivity estimation.

4.6. TFP estimation and price changes

We expect our micro level productivity measures to be affected both by the non aligned paths of domestic and export prices via the price indexes required to produce constant price estimates.

We estimate firm productivity based on Olley and Pakes (1996). In the following, we will refer to it as TFP. To study the role of prices and base year choices, we compare the estimation of firm TFP using the firm specific price indexes described above but adopting alternatively all of the sample years (1997 to 2005) as our base year.

In the next sections we report the main effects of base year changes in the estimation of production function coefficients, micro level firm productivity and performance indicators based on them.

4.6.1. TFP estimation

In table 9 we provide the estimated Olley-Pakes (1996) production function coefficients obtained from constant price output and input variables at selected base years.[23]

[23]For the estimation we used the complete database, including the 2002 data on output, labor, capital and materials which were present. For 2002 we could not however use exports and domestic sales data to weigh price indexes, so we use the weights from adjacent years.

Table 9
Estimated production function coefficients
by base year

Base	Capital		Labor		Materials	
year	Coeff	SE	Coeff	SE	Coeff	SE
1997	0,08	0,04	0,40	0,03	0,55	0,02
1999	0,07	0,04	0,40	0,02	0,55	0,02
2001	0,14	0,04	0,39	0,02	0,56	0,02
2003	0,15	0,03	0,35	0,03	0,58	0,02
2005	0,10	0,03	0,35	0,03	0,58	0,02

Estimation based on Olley-Pakes (1996).
Source: INE database.

We obtain some sensitivity of the estimated production function coefficients to base year choice. The estimated capital coefficients increase in the crisis years, which may be related to the mechanism by which the capital services indicator is constructed. Capital services are proportional to the depreciated stock. Imported and domestically purchased components of investment are deflated separately, but in a given period, purchases are only a fraction of the capital stock. Firms may have held back their investment decisions in crisis years. Hence in those years there might be less contribution of new capital goods incorporated into the implicit capital services price. Further, their impact on the stock is smoothed across the following periods according to its imputed service lifetime.

Labor is the only input measured in true physical units (in our case the number of employees). Using a base year closer to the last in our sample (with increased export and domestic prices) would naturally cause its impact on output, as measured by the respective coefficient, to become smaller. The opposite is the case with respect to the material inputs coefficient, that increases when the base year is closer to the end of sample years.

When considering micro productivity estimates, we do not observe differences in the time series paths of representative statistics of the distribution when different base years are considered. To avoid sample composition effects, we provide in Table 10 micro level tfp median growth rates and their interquartile ranges for selected base years.

Table 10
Firm-level TFP growth
Median and interquartile range
by year and base year

	Base year									
	1997		1999		2001		2003		2005	
	p50	iq	p50	iq	p50	iq	p50	iq	p50	iq
1998	-0,02	0,20	-0,03	0,20	-0,03	0,21	-0,04	0,24	-0,03	0,22
1999	-0,02	0,19	-0,02	0,19	-0,02	0,20	-0,02	0,22	-0,02	0,21
2000	0,00	0,19	0,00	0,19	0,00	0,20	0,00	0,22	0,00	0,20
2001	0,01	0,22	0,01	0,23	0,01	0,22	0,01	0,24	0,01	0,23
2002	0,01	0,35	0,01	0,36	0,03	0,34	0,02	0,33	0,01	0,34
2003	-0,06	0,28	-0,06	0,28	-0,06	0,28	-0,06	0,27	-0,06	0,27
2004	0,01	0,25	0,01	0,25	0,00	0,24	0,01	0,22	0,01	0,22
2005	-0,01	0,22	-0,01	0,22	-0,01	0,21	-0,01	0,20	-0,01	0,20

Source: INE database.

When observing sample averages of inputs and output variables by year across firms (not reported), the graphs of their sample averages all show parallel upward shifts when the base year moves from 1997 to 2005, with a sharp step in 2003. This yields average firm-level (ln)TFP time series (not reported) that are also parallel.

However such statistics do not represent all of the changes in the distribution of estimated TFP across firms. We examine next some of the changes in the cross sectional dimension, particularly the exporter-non exporter relative performance and TFP differential.

4.6.2. Relative performance of exporters *vs.* non-exporters

More relevant to our estimation, we find that the exporters productivity differential measurement is sensitive to price base year choice. We obtain a result that is not frequent in the literature, i.e. the exporter-non exporter average productivity differentials change sign when base year changes. Table 11 shows the average ln TFP differential of the exporter and non exporter firm subsets, by year and base year.

Table 11
Average ln(TFP) differential
exporters vs non-exporters
by year and base year

	Base year				
year	1997	1999	2001	2003	2005
1997	-0,03	-0,14	-0,11	0,05	-0,01
1998	-0,04	-0,16	-0,12	0,04	-0,02
1999	0,00	-0,12	-0,08	0,08	0,02
2000	0,08	-0,04	0,00	0,15	0,10
2001	0,07	-0,04	-0,01	0,14	0,09
2002	.	.	.	.	.
2003	0,04	-0,07	-0,03	0,10	0,06
2004	-0,01	-0,12	-0,09	0,05	0,02
2005	0,00	-0,11	-0,08	0,06	0,02

Source: INE database.

The time series pattern of the exporter productivity differentials seems similar across base years, but the usual result in the literature, i.e. productivity differential in favor of exporters being positive (for instance see Bernard and Jensen, 1995, 2004) is reversed, particularly for base years 1999 and 2001 when real exchange rate was overvalued, which give all-negative exporter productivity premiums. Exporters seem to be less productive than non exporters in those years. The differentials change back to all positive only for base year 2003, in which the relative output price is strongest.

Exporter-non exporter productivity differentials are sensitive to the choice of base year. This would be not noticeable if data in which such sharp variations in relative prices are not present were used. Our adoption of 'firm specific' prices intends to control for changes in relative output prices, to make TFP measures comparable between exporters and non-exporters, but this was not enough in view of the large price swings. Also, the base year choice effect would have been stronger if firm data were deflated by the average sector price indexes instead of using firm level sales weighted average of domestic and export prices.

We briefly explore if this sign reversal is the effect of different estimated coefficients, or is mainly the consequence of different valuation of output and inputs across firms. So we run the estimation of firm level TFP with firm variables measured at different base years, but keeping the production function coefficients constant and equal to those estimated for data at 1997 prices. The results are displayed in Table 12.

Table 12
Average ln(TFP) differential
exporters vs non-exporters
by year and base year

Using base year 1997 estimated
production function coefficients

	Base year				
year	1997	1999	2001	2003	2005
1997	-0,03	-0,09	-0,05	0,09	0,02
1998	-0,04	-0,10	-0,06	0,08	0,01
1999	0,00	-0,06	-0,02	0,12	0,05
2000	0,08	0,02	0,06	0,19	0,13
2001	0,07	0,01	0,05	0,18	0,12
2002	.	.	.	.	.
2003	0,04	-0,02	0,03	0,15	0,09
2004	-0,01	-0,06	-0,02	0,11	0,06
2005	0,00	-0,05	-0,01	0,11	0,05

Source: INE database.

The time-series pattern is the same as for the exporter productivity differential computed each with the set of coefficients corresponding to the base year at which the variables in the production function equation are measured. However, the exporter premium series are shifted upward. There are negatives in the base 1999 and 2001 series, but not all of them, and differentials base 2003 and 2005 are all positive. The ordering of the series in the vertical axis is the same for both alternative sets of coefficients. Our conclusion is that measurement of firm level variables and coefficient estimation reinforce one another in the production of the sign reversal of estimated coefficients.

Summarizing the effect of base year choice, for given production function coefficients, an exporting firm would find its output relatively deflated in relative terms to a non exporter if the base year is one in which the exchange rate is comparatively small. Additionally, a larger proportion of its inputs would be imported when compared to a non exporter. A low exchange rate base year would mean less input contribution (which would be subtracted from a micro level productivity measure), hence this will make exporters look more productive than non exporters.

In the next sections we undertake the estimation of determinants of two relevant dimensions of firm performance, i.e. the probability of entry in the export markets and the export share. We try to design an estimation strategy that takes into account the measurement issues discussed and tries to control for their influence.

4.7. Export performance estimation

4.7.1. Export status determinants

The empirical analysis of firm export entry decisions has been based on the difference in firms profits when exporting and when not exporting, i.e. the export activity net revenues, as for instance in Bernard and Jensen (2004). We should compare the net revenues of an exporter π_x at given export prices and productivity to those it would obtain if optimally chose to export zero units and produce for the domestic market only (π_d).[24] If we assume a fixed export cost $e\lambda_x$, a firm would export if the difference in net revenues is greater than $e\lambda_x$:

$$\pi_x(P_x, \omega, w, \rho) - \pi_d(\omega, w, \rho) - e\lambda_x > 0$$

In a discrete choice framework, a firm's exporting status is a function of observable firm and market characteristics affecting its behavior as well as of unobservable firm specific heterogeneity. A key feature is to introduce the dependence of the current export status on past periods' status. Bernard and Jensen (2004) as before Roberts and Tybout (1997) link present and past export status by their impact on exporting fixed costs (and this fits naturally in the context of persistence of the export condition that is observed in the data). This introduces the complication that the current period outcome is dependent on the complete series of the firm's export status in periods going back to some initial condition that in general may not coincide with the sample initial period. The first approach to this problem was the paper by Heckman (1981). Wooldridge (2005) suggests assumptions on the distribution of the unobserved individual effects conditional on the initial value and the exogenous variables, and obtains a conditional maximum likelihood estimation.

We define an indicator variable Y_{it} taking the value 1 if the firm exports and 0 if it does not in period t such that:

$$Y_{it} = \begin{cases} 1 \quad if \quad \pi_x(eP_{\$}, \omega, w, \rho, Y_{it-1}) - \pi_d(\omega, w, \rho) - e\lambda_x > 0 \\ 0 \quad otherwise \end{cases}$$

A key independent variable is the firm export price, and it is only available for firms that export. We impute for non exporters the average sector/size stratum export price index. We compute a firm level wage per worker index, by dividing the nominal wage bill by firm employment, and constructing an index equal to 100 in the base year. We also include as a regressor the price index of of imported material inputs.

We cannot observe the export constraint condition of a firm. If the export constraint is related to access to financing, liquidity constraint can be modeled as being negatively related to $P_{\$}$ and ω. If the constraint were to become tighter in face of a devaluation, the effect of o $eP_{\$}$ in the probability of exporting would be dampened for that reason. Also, we cannot observe a firm's markup ρ. If *pass-through* were complete, the export decisions would be driven only by the export price, and domestic price and production would follow. An indicator that would help to detect the magnitude of firm markup is the relative export price $eP_{\$}/Pd$. In a context of unconstrained firms it would be related -for exporters- to the inverse of firm markup $1/\rho$.

For our panel estimation, we do not have export-domestic sales data for 2002 (though output and production inputs are present and we estimate TFP for that year). We opted for constructing a panel of biannual observations including 1997, 1999, 2001, 2003 and 2005. The observations refer to each year, but firms are observed every two years, and changes are constructed with respect to two years before.

[24] For instance, in models as Melitz (2003) productivity induces an ordering of threshold levels, i.e. productivity is higher for exporters that for non exporters.

We performed the estimation for all base years, and report only results for data at 2005 prices, for a simple linear probability model (in which however we do not observe predictions out of the $[0,1]$ interval), and for the Wooldrige (2005) dynamic probit estimation procedure. The dependent variable is the same at all base years. Results are displayed in Table 13.

Table 13
Probability of exporting
Linear probability and dynamic probit models

	Linear probability model		Wooldridge dynamic probit	
	Coeff	Sd	Coeff	Sd
lagged exporter status	0.791***	(0.0135)	1.294***	(0.179)
ln(TFP)	0.0175	(0.0145)	0.201	(0.137)
ln(wage)	0.00481	(0.00540)	0.0107	(0.0537)
ln(imported input price)	-0.113	(0.108)	-0.707	(0.921)
ln(export price)	0.0166	(0.0789)	0.354	(0.648)
ln(relative export price)	-0.00993	(0.0409)	-0.266	(0.345)

Source: INE database, at 2005 constant prices.
Year dummy variables included.
Standard errors in parentheses.
*** $p < 0{,}01$, ** $p < 0{,}05$, * $p < 0{,}1$.

Both estimations are similar qualitiatively and quantitatively. We've obtained an established result in the literature as is the significance and magnitude of the lagged export status coefficient in the dynamic probit of firm's export status. This has been interpreted as a test on the significance of sunk costs of the exporting activity and our data share this feature, first described by Roberts and Tybout (1997) and Bernard and Jensen (2004).

The firm-level covariates do not get statistically significant coefficients, but it may be noted that this is not uncommon in the export decisions literature, in which the main focus of interest is in fixed costs and the significance of the lagged export status variable. However the signs suggest a direction of impacts nos incosistent with our view of firms decisions.

Having performed estimations at different base year prices, some variables sometimes change the sign of their impact depending on the reference prices being that of a low or a high real exchange rate sub period.[25] Total factor productivity is negatively or not significantly associated to export status in some of the overvaluation years, which is consistent with our previous results on exporter productivity premiums. However higher wages are always associated to exporting activity, which coincides with the findings of Bernard and Jensen (2004), who associate this result to higher quality labor in exporting firms. Imported input prices have a negative impact in export status for most of the alternative base years.

Though not statistically significant, the negative sign of the relative export price points in the direction of changes in export and domestic output quantities consistent with at least to a some extent some degree of export constraint in some firms.

[25]Estimations for all base years are available on request.

4.7.2. Export share of exporting firms

Output allocation between domestic and export sales is not frequently studied in the literature. An example is the paper by Berman, Berthou and Héricourt (2015), which presents evidence in favor of a certain degree of complementarity of exports and domestic sales.

Based on the expression for the export share, we undertake the estimation of a regression equation for the export share of exporters as a function of the export price, the export and domestic price ratio, the wage index, the domestic/import input price ratio, and firm level estimated total factor productivity.

A regression model for a dependent variable which is a proportion -bound in the $[0, 1]$ interval- places some constraints on the error term. The bounds imply that the effect of explanatory variables tends to be non-linear (the effect of an x will not be constant across its range), and the variance tends to decrease when the mean gets closer to zero or one. Wooldridge and Papke (2008) propose an estimation procedure. We consider exporters, i.e. only firms on the intensive margin, so there will be no zeros in our proportions. The results are shown in Table 14.

Table 14
Export share
Fractional logit and model in differences

	Fractional logit	
ln(tfp)	-0.0505	(0.0865)
ln(wage)	0.105***	(0.0346)
ln(imported input price)ipmim	-0.188	(0.438)
ln(export price)	-0.254	(0.448)
ln(relative price)	-1.410***	(0.196)

Source: INE database at 2005 prices.
Year dummy variables included in fractional logit.
Standard errors in parentheses.
*** $p < 0{,}01$, ** $p < 0{,}05$, * $p < 0{,}1$.

Once controlling for the export price, we obtain a significant and negative sign for the relative export price. The signs of the (non significant) coefficients coincide with those obtained in the export status estimation, with the exception of the export price..

4.8. Conclusions

In this paper we analyze firm export performance in the context of exchange rate fluctuations. First, we provided a microeconomic rationale for some salient features of observed behavior in export status and export share, particularly less than full exchange rate to domestic price *pass-through* and a negative correlation of changes in export shares with the changes in the relative export price. We set to analyze econometric evidence of such phenomena.

In the context of large relative price changes, measurement issues are of importance, since firm level statistics are estimated using constant year base prices values. Choice of base year is relevant to the results obtained in measures of firm performance, i.e. total factor productivity and export productivity premium estimates. In some cases we obtain reversals of the estimated signs for some results generally obtained in the literature.

We undertook an estimation of the impact of exchange rate and firm characteristics changes in firm level export response, as well as in entry and exit in export market. Our estimations recover an impact which is qualitatively consistent with our microeconomic model. We do not believe however that we obtained measures that are robust to base year choices. An issue for further investigation is the possibility of using firm prices instead of sector level aggregates to describe firm activity.

References

[1] Foster, L., J. Haltiwanger, and C. Syverson, (2008), Reallocation, firm turnover, and efficiency: selection on productivity or profitability? *American Economic Review*, 98(1) 394-425.

[2] Klette, T. J., and Z. Griliches, (1996), The inconsistency of common scale estimators when output prices are unobserved and endogenous. *Journal of Applied Econometrics*, vol. 11, no. 4, pp. 343-361.

[3] Berman, N, A. Berthou and J. Héricourt, (2015), Export dynamics and sales at home, *Journal of International Economics* 96 (2015) 298-310.

[4] Levinsohn, J. and A. Petrin, (2003), Estimating production functions using inputs to control for unobservables. *Review of Economic Studies* 70: 317-341.

[5] Olley, G. and A. Pakes, (1996), The dynamics of productivity in the telecommunications equipment industry. *Econometrica* 64: 1263-1297.

[6] Licandro, O. and C. Casacuberta, (2017), Domestic price pass-through under large devaluations, forthcoming.

[7] Halpern, L., M. Koren, and A. Szeidl, (2015), Imported inputs and productivity, *American Economic Review* 105(12): 3660-3703.

[8] Bernard, A. and J. B. Jensen, (1995), Exporters, jobs and wages in US manufacturing. *Brookings papers in Economic Activity. Microeconomics*, Volume 1995, pp. 67-112.

[9] Bernard, A. and J. B. Jensen, (2004), Why some firms export, *Review of Economics and Statistics*, Vol. 86, No. 2 pp. 561-569.

[10] Roberts, M. J. and J. R. Tybout, (1997), The decision to export in Colombia: an empirical model of entry with sunk costs, *American Economic Review*, Vol. 87, No. 4, pp. 545-564.

[11] Melitz, M.J. (2003), The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica* 71 (6): 1695-1725.

[12] Heckman, J., (1981), Statistical models for discrete panel data, in C. Manski and D. McFadden, eds., Structural analysis of discrete data with econometric applications, MIT Press, Cambridge.

[13] Wooldridge, J., (2005), Simple solutions to the Initial conditions problem in dynamic nonlinear panel data models with unobserved heterogeneity, *Journal of Applied Econometrics*, 20, pp. 39-54.

[14] Papke, L. and J. M. Wooldridge (2008), Panel data methods for fractional response variables with an application to test pass rates, *Journal of Econometrics*, 145 (2008) 121-133

4.A. Price indexes

Gross revenues are deflated using a price index that reflects variations in prices of exported (Q_{xit}) and domestically sold (Q_{dit}) production. A price index (for instance Laspeyres) would take the quotient of sales in base period 1 at period t prices over sales in period 1 at base year prices. Assuming a firm sells a product domestically at price P_{dit}, being P_{xit} the (domestic currency) export price, for a given firm the price index would be:

$$IP_{it} = \frac{Q_{xi1}P_{xit} + Q_{di1}P_{dit}}{Q_{xi1}P_{xi1} + Q_{di1}P_{di1}} = \frac{Q_{xi1}P_{xi1}}{Q_{xi1}P_{xi1} + Q_{di1}P_{di1}} \cdot \frac{P_{xit}}{P_{xi1}} + \frac{Q_{di1}P_{di1}}{Q_{xi1}P_{xi1} + Q_{di1}P_{di1}} \cdot \frac{P_{dit}}{P_{di1}}$$

A Laspeyres index is the ratio of the base period goods basket at each period's prices, and the same basket valued at base period prices. It can be shown to be a weighted average of price variations of exported and domestically sold production, where the weights are the export/sales and domestic sales/total sales ratios in the base period.

In turn, a Paasche type index would consider the ratio of each period's basket of goods valued at current prices, and the same basket valued at base period prices:

$$IP_{it} = \frac{Q_{xit}P_{xit} + Q_{dit}P_{dit}}{Q_{xit}P_{xi1} + Q_{dit}P_{di1}} = \left[\frac{Q_{xit}P_{xit}}{Q_{xit}P_{xit} + Q_{dit}P_{dit}} \left(\frac{P_{xit}}{P_{xi1}}\right)^{-1} + \frac{Q_{dit}P_{dit}}{Q_{xit}P_{xit} + Q_{dit}P_{dit}} \left(\frac{P_{dit}}{P_{di1}}\right)^{-1}\right]^{-1}$$

In this case the weights for the weighted average of price variations of exported and domestically sold production are the export/sales and domestic sales/total sales ratios valued at current prices.

4.B. Tables

Table A1
Share of exports
in firm revenue of exporters
for the aggregate sample
by year

Year	Current prices	Constant 1997 prices
1997	0,45	0,43
1998	0,40	0,41
1999	0,37	0,41
2000	0,39	0,44
2001	0,39	0,43
2002	.	.
2003	0,49	0,46
2004	0,50	0,49
2005	0,49	0,52

Source: INE database.
Exporters defined as firms with exports > 0 in year t.

Table A2
Share of exports
in firm revenue of exporters
Median firm level data, by year

Year	Current prices	Constant 1997 prices
1997	0,31	0,32
1998	0,33	0,38
1999	0,32	0,36
2000	0,33	0,36
2001	0,32	0,35
2002	.	.
2003	0,40	0,37
2004	0,32	0,30
2005	0,31	0,28

Source: INE database.
Exporters defined as firms with exports > 0 in year t.

Table A3
Proportion of firms
that export
by year

	All firms	Firms in all years
1997	0.40	0.40
1998	0.40	0.41
1999	0.39	0.41
2000	0.40	0.43
2001	0.37	0.42
2002	.	.
2003	0.34	0.40
2004	0.33	0.40
2005	0.35	0.41

Source: INE database.
Exporters defined as firms with exports > 0 in year t.

4.C. Graphs

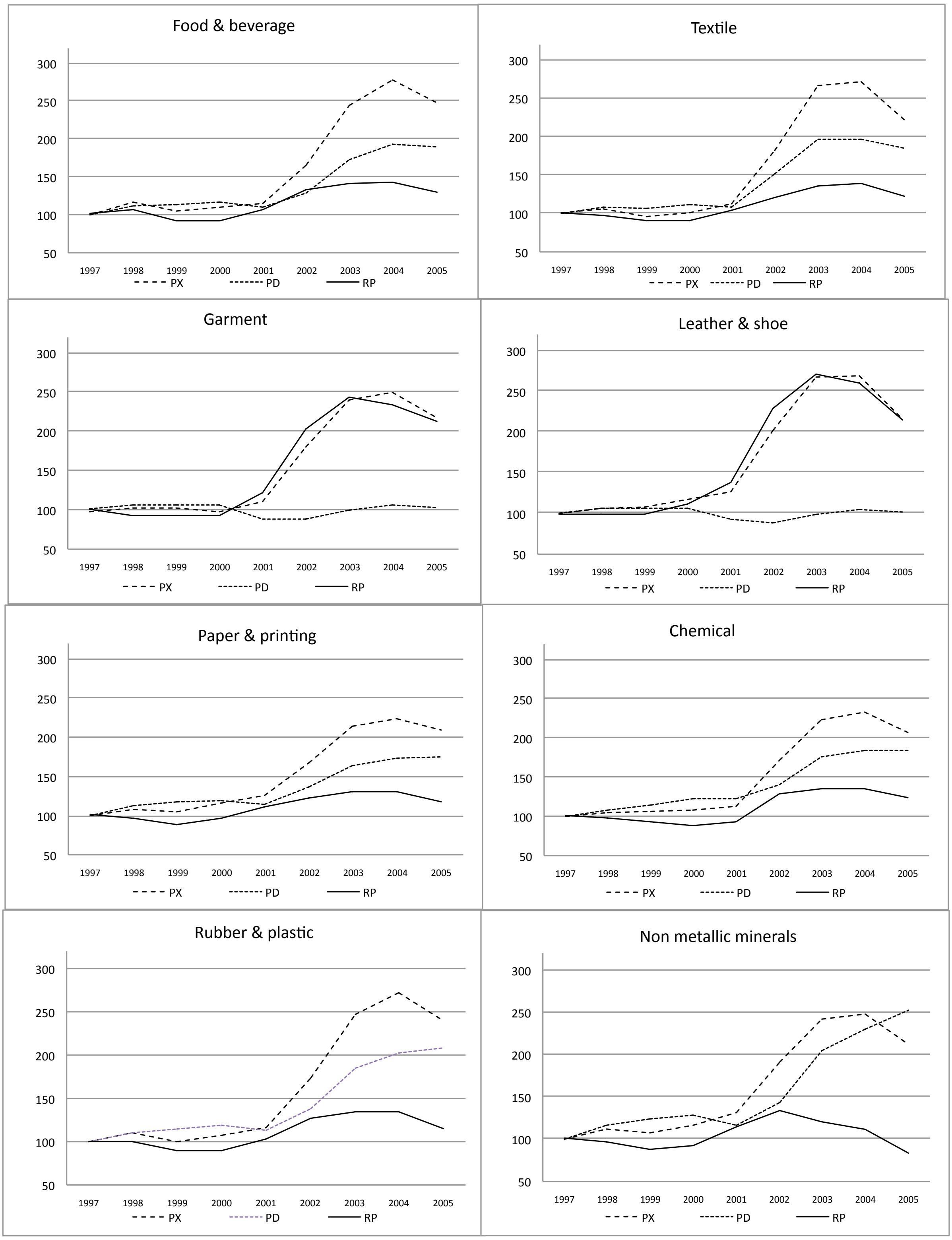
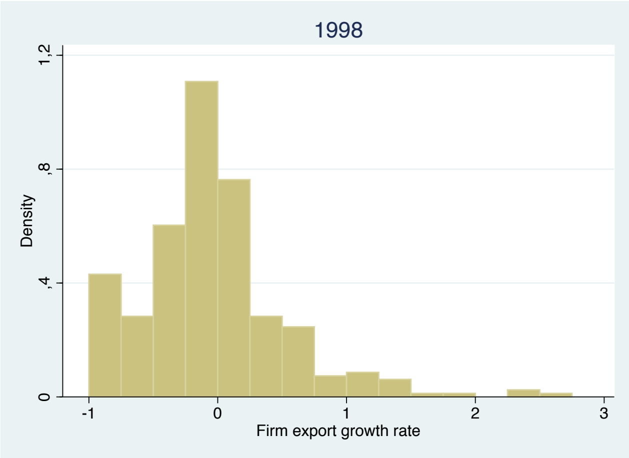
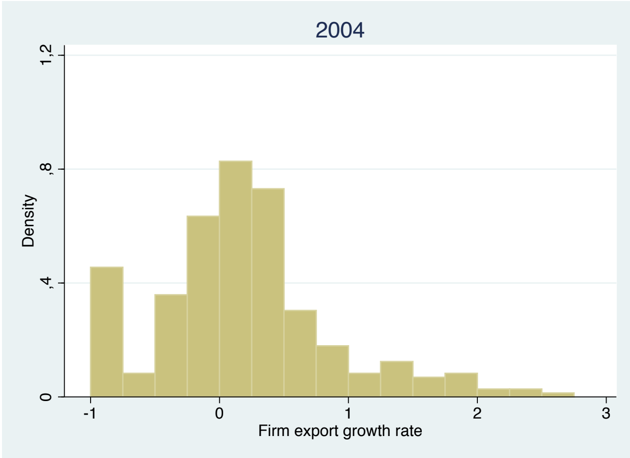


Figura 4.5: Domestic, export and relative output price, by sector

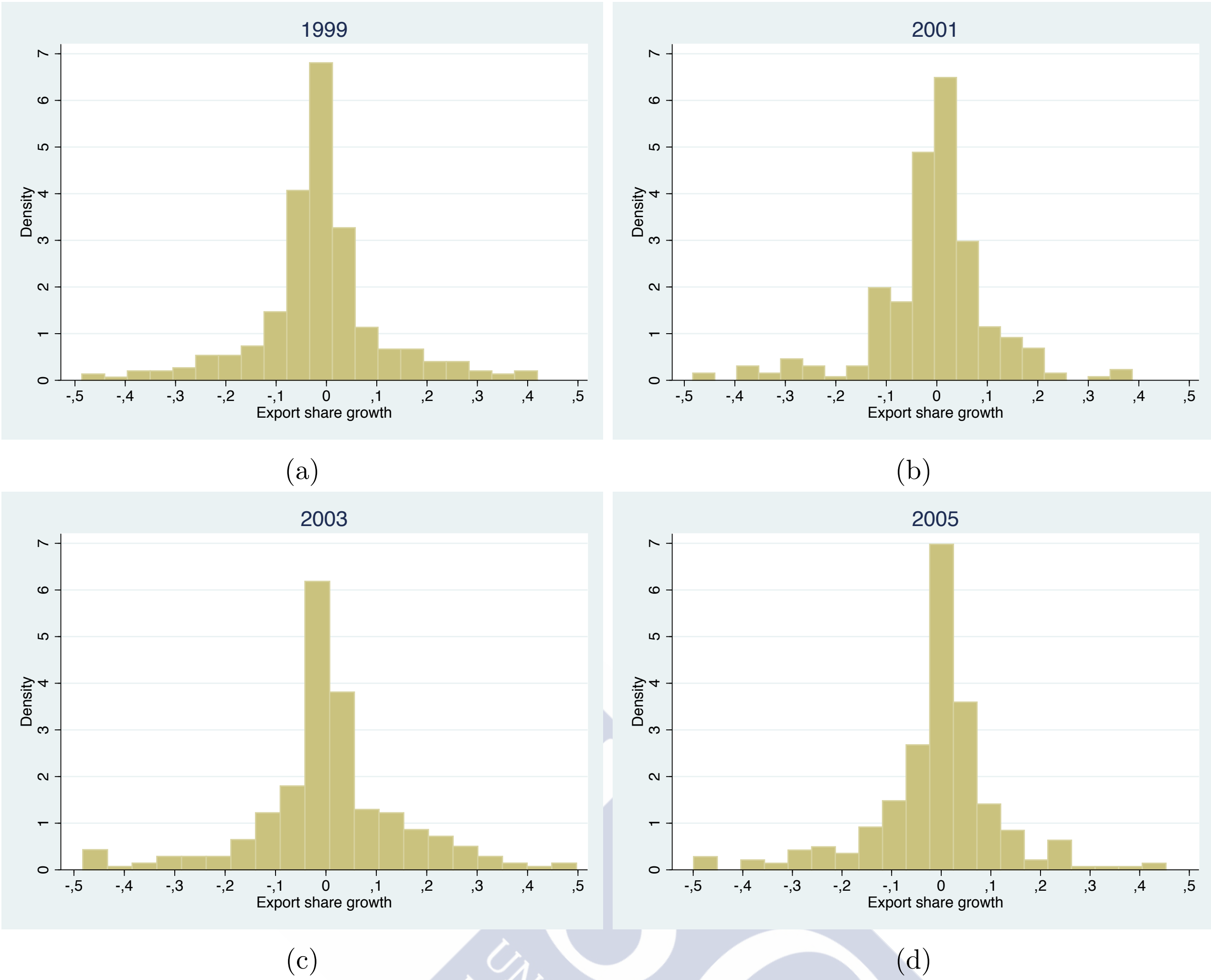


(a)



(b)

Figura 4.6: Histogram of firm level exports annual growth rate
Values below 95th pctile



(a) (b)

(c) (d)

Figura 4.7: Histogram - firm export share 2 year growth
Values between 1st and 95th pctiles

5 The effect of input and output protection on productivity in Uruguay

Resumen

Este trabajo analiza el impacto en la productividad de los cambios en la protección comercial en los insumos y los bienes finales de las empresas manufactureras en Uruguay entre 1988 y 2001 para un panel de empresas. Se estima la productividad total de los factores, controlando por decisiones de niveles de factores endógenas así como shocks de demanda y precios. El método se adapta para evaluar los impactos tanto de protección en bienes finales como en insumos. Las estimaciones de productividad controladas son la variable independiente en una segunda etapa.en que se estima el impacto de la protección. Se obtiene un impacto significativo, medido por los aranceles de nación más favorecida, de la protección arancelaria en la productividad total de los factores de las empresas uruguayas en el período en que la apertura comercial -tanto multiilateral como en el marco del Mercosur- fue más intensa. Las reducciones de aranceles sobre los productos de las empresas incrementan la productividad, mientras que se obtiene el efecto inverso con los aranceles en los insumos: reducciones de los mismos reducen significativamente la productividad total de los factores.

Abstract

This paper analyzes the impact on productivity of changes in trade protection in inputs and final goods for manufacturing firms in Uruguay, for a panel between 1988 and 2001. Firm-level total factor productivity is estimated, controlling for endogenous factor choices as well as for demand shocks and unobserved prices. The methodology is adapted to evaluate both the impacts of input as well as product protection. Controlled productivity estimates are the dependent variable in a second stage in which the tariff impact is estimated. A significant impact of protection, as measured by the most favored nation tariffs was obtained on firm level total factor productivity, in the period in which Uruguay trade openness process became more intense, both multilaterally and in the context of Mercosur. Tariff reductions on final goods enhance firm productivity, while the opposite effect is obtained with respect to input protection: reductions in input tariffs reduce significantly total factor productivity.

5.1. Introduction

It has been traditionally argued that trade liberalization produces static gains from trade in developing economies. More recent literature stresses the more relevant dynamic benefits from productivity enhancement effects of openness. Particularly, the literature spanned by heterogeneous-firm trade models started by Melitz (2003) emphasizes the selection mechanism by which, in the face of trade liberalization, resource reallocation across firms lead to productivity growth.

The effect of trade openness on firms' productivity has been widely researched in the international literature. Trefler (2004) uses plant-level data to analyse the impacts of the Canada-U.S. Free Trade Agreement on productivity and employment of Canadian firms. Bernard et al. (2006) investigate the effect of changes in trade costs (measured as the sum of ad valorem duty and ad valorem freight and insurance rates) on U.S. manufacturing plants' productivity. Amiti and Konings (2007) estimate the effects of trade liberalization on plant productivity in Indonesia, finding that reducing tariffs, especially input tariffs, has an enhancing effect on productivity, and that importers enjoy larger gains from liberalization (reflecting direct benefits from higher-quality foreign inputs, more differentiated varieties of inputs and/or learning effects). Fernandes (2007), using Colombian data, also finds a strong positive impact of trade liberalization on plant productivity, while discussing several shortcomings of the usual econometric estimates of such effect. Other references for Latin American countries include Pavcnik (2002) for Chile, Lopez-Cordova and Mesquita (2003) for Brazil and Mexico, and Muendler (2004) who analyzes the case of Brazil.

More recently, De Loecker (2011) argues that firm-level studies on the impact of trade liberalization are subject to several shortcomings that may lead to biased estimates. Particularly, the standard use of deflated sales in the production function may introduce a spurious relationship between measured productivity and trade openness, given by the impact of liberalization on prices and demand. He proposes a new methodological approach to control for these unobserved effects, which allows identifying the impact on actual productivity (i.e., isolating the productivity response to reduced trade protection from the price and demand responses). Using data from the Belgian textile industry, he finds that, while positive and significant, the estimated effect is quite smaller than that obtained with standard measures of productivity.

Uruguay is an interesting case to evaluate the impact of trade protection on economic efficiency. In the early 1990s this country deepened the trade liberalization process initiated in the 1970s, combining unilateral tariff reductions with regional integration in the framework of the Southern Common Market (Mercosur). Newly available data allow addressing the impact of this liberalization process based on firm-level specific tariff measures, in line with the recent literature on firm heterogeneity, productivity and trade, and departing from previous empirical exercises based on sector-level tariff variation.

For Uruguay, the only previous study on the effect of trade protection on productivity using microdata is Casacuberta, Fachola and Gandelman (2004). They provide a first approach to the estimation of the impact of trade policies on Uruguayan firm's behaviour, exploring the relationship between trade openness (measured by four-digit sector average tariffs) and firm-level total factor productivity (TFP). Their results show a significant productivity enhancing effect of tariffs reduction between 1988 and 1995.

Another important caveat of most empirical work on the link between trade openness and firms' productivity is the use of industry-level tariff measures (e.g., Trefler, 2004; Bernard et al., 2006; Fernandes, 2007). To the extent that the composition of product bundles differs across firms within industries, measured changes in tariff rates may under- or overestimate the changes actually faced by individual firms. In this sense, an important contribution of our analysis is the use of firm-specific tariff measures.

We study the effect of trade protection on Uruguayan manufacturing firm's productivity using a panel of enterprises from 1988 to 2001. We estimate firm-level TFP based on De Loecker (2011) and relate this measure to firm-specific output and input protection indicators, computed as the average tariff within the Harmonized System (HS) classes containing all firm's products and inputs, respectively. For comparison purposes, we consider alternatively the usual industry-level tariff averages.

The paper is organized as follows. In Section 2 we review the earlier methodologies applied to estimate trade protection effects on TFP (two-step and direct approaches), and discuss our adaptation of the methodology proposed by De Loecker (2011) to our case. In Section 3 we describe the manufacturing and protection data used in this study. In Section 4 we present the econometric results. Finally, in Section 5 we sketch the preliminary conclusions.

5.2. Identifying the effect of trade protection on productivity

We intend to build upon the identification strategy proposed by De Loecker (2011) (DL in what follows) to accomodate input and output tariff effects analysis. DL addresses some shortcomings of the methodologies used previously in the literature, which have been labeled as the two-step and the single equation or direct approaches.

Two-step approach: In the traditional two-step approach (see for instance Amiti and Konings, 2007), a standard production function is first estimated in order to retrieve firm-level productivity measures, while in a second step that estimated productivity is regressed on firm or sector-level protection measures and controls. The customary methodologies for measuring TFP are the semi-parametric (proxy-based) methods proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003), which control for simultaneity between productivity shocks and input decisions.[1]

The Cobb-Douglas production function estimated in the first step is:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \omega_{it} + u_{it} \tag{5.1}$$

where y_{it} is output, l_{it} labour, k_{it} capital and m_{it} intermediate inputs (all in logarithms) of firm i in period t; ω_{it} is a firm-specific productivity shock, known to the firm and correlated with its flexible input choices; and u_{it} is an unpredictable i.i.d. shock to production that does not affect firm's decisions. From the estimated coefficients, TFP is retrieved as:

[1]When firms receive a positive productivity shock, they may respond by using more inputs. Under these conditions, the ordinary least squares (OLS) estimator will result in biased parameter estimates and, consequently, in biased estimates of productivity.

$$\widehat{tfp}_{it} = y_{it} - \widehat{\beta}_l l_{it} + \widehat{\beta}_k k_{it} + \widehat{\beta}_m m_{it}$$

where $\widehat{tfp}_{it}$ is (log) of TFP of firm i in period t.

In a second step, the firm-level productivity estimate is regressed on trade protection measures, such as output tariffs:

$$\widehat{tfp}_{it} = \gamma_0 + \alpha_i + \gamma_1 t_{it} + \gamma_2 X_{it} + v_{it} \tag{5.2}$$

where α_i are fixed effects to control for unobservable heterogeneity at the firm level, t_{it} are final goods tariffs, and X_{it} are firm-level controls. A reduction in protection on final goods would induce productivity enhancement (i.e., $\gamma_1 < 0$), due to import competition compelling domestic firms to increase their efficiency or forcing the exit of the least productive. Additional regressors could account for the effect of reduced protection on firm's inputs, regarding which there might be two views. In the spirit of Corden (1971), lower input tariffs could lead to lower productivity since the effective protection increases, and incentives to shift to more efficient production techniques are reduced. On the other hand, lower input tariffs may lead to productivity gains as firms obtain access to a larger variety of and/or better inputs (in terms of quality and incorporated technology).

Direct approach: It is argued that the second-step equation (equation (2)) is affected by the presence of serial correlation, since it does not control for lagged productivity, which is implied by the assumptions of the proxy-based productivity estimation procedures (Fernandes, 2007). Also, the Markov process assumed by these methods implies that current firm productivity, conditional on lagged productivity, should be a surprise to firms. The second-step equation nonetheless allows for impacts of variables that are known to the firm in advance, like trade policy, and this may bias the estimated productivity measures and the impact of trade policy on productivity. The direct or single equation approach addresses these shortcomings by including trade policy directly as a regressor in the production function. Thus, the estimated equation is:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \gamma_1 t_{it} + \gamma_2 X_{it} + \omega_{it} + u_{it} \tag{5.3}$$

In this extension of the proxy-based productivity estimation methods, the effect of tariffs on productivity can then be directly inferred from the size, sign and significance of parameter γ_1.

Integrated estimation: Based on the ideas of Klette and Griliches (1996), DL provides a general critique to both the two-step and the direct traditional approaches. As physical output is usually not observed, most empirical work on the impact of trade policy changes on firms' efficiency relies on productivity measures estimated from industry-wide deflated revenues (i.e., firm-level sales deflated with industry-level producer price indices). This may lead to biased productivity estimates, as the price error (i.e., the difference between a firm's price and the industry price index) might be correlated with the firm's input choices.

Also, productivity estimates will contain price and demand variation, which potentially introduces an spurious relationship between measured productivity and trade liberalization through the impact of liberalization on prices and demand. Thus, in order for the effect of reduced trade protection on actual productivity to be identified, in addition to factor usage endogeneity, unobserved prices and demand shocks need to be controlled for.

DL's empirical model introduces a demand system in the standard production function framework. He relies on firm-level protection measures (firm averages of product-level import quotas) to construct demand shifters that can be incorporated into a Levinsohn-Petrin or Olley-Pakes-type productivity estimation:

$$\widetilde{r}_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_s q_{st} + \omega^*_{it} + \xi^*_{it} + u_{it} \tag{5.4}$$

being $\widetilde{r}_{it}$ the log of firm's deflated revenue. The difference with the typical first-step equation is the inclusion of q_{st}, a sector-level aggregate demand indicator; and ξ^*_{it}, an unobserved demand shock.[2]

We modify DL's methodology to study the effect of input and output trade protection on Uruguayan manufacturing firms' productivity applying an adjusted two-step approach. First, we estimate firms' TFP using a DL-type corrected Levinsohn and Petrin (2003) method. In the second stage we relate this TFP measure to firm-specific output and input protection indicators.

The firms in our panel generally produce several products within a single four-digit International Standard Industrial Classification (ISIC) sector, but there are also some multi-industry firms. In this respect, we follow DL's methodology extension to multi-product and multi-sector firms. We compute the aggregate demand indicator q_{st}, the sector-level aggregate expenditure in all varieties of the differentiated good, by four-digit ISIC industries.[3] This aggregation level also corresponds with our price data used to obtain deflated revenues (i.e., our left hand side output variable).

We treat firm's product and input bundles as fixed, and our analysis abstracts from the issue of whether (and how) changes in protection affect them. We follow DL in assuming identical production functions for each of the products and have inputs distributed across products in proportion to the number of products produced by the firm. This implies that the fraction of each of total inputs used in production of product j, c_{ij} is equal to J^{-1}, with J being the number of products produced by the firm. This gives the equivalent number of products that would have corresponded to a uniform distribution.

For each good j the production function is given by:

$$Q_{ijt} = \left(c_{ijt} L_{it}\right)^{\alpha_k} \left(c_{ijt} K_{it}\right)^{\alpha_l} \left(c_{ijt} M_{it}\right)^{\alpha_m} exp\left(\omega_{it}\right) = c^{\gamma}_{it} Q_{it} = J^{-\gamma} Q_{it}$$

Hence an expression is obtained for firm level revenue, $R_{it} = \sum_j P_{ijt} Q_{ijt}$, using the CES demand given by

$$Q_{ijt} = Q_{st} \left(\frac{P_{ijt}}{P_{st}}\right)^{\eta_s} exp(\xi_{it})$$

where different substitution patterns are allowed for each sector s. The expression is:

$$R_{it} = P_{st} Q_{st}^{-\frac{1}{\eta_s}} \left(exp(\xi_{it})\right)^{-\frac{1}{\eta_s}} Q_{it}^{\frac{\eta_s+1}{\eta_s}} J_{it}^{\left(1-\frac{\gamma(\eta_s+1)}{\eta_s}\right)}$$

[2]The terms ω^*_{it} and ξ^*_{it} correspond, respectively, to the unobserved productivity (ω_{it}) and demand (ξ_{it}) shocks, multiplied by a term that depends on the elasticities of substitution in the constant elasticity of substitution (CES) demand system considered by DL. For details, we refer the reader to De Loecker (2011).

[3]We add for each 4 digit ISIC sector domestic gross production plus imports, at basic prices.

Taking logs we get:

$$\widetilde{r}_{it} = \beta_{np} np_{it} + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_s q_{st} + \omega^*_{it} + \xi^*_{it} + \nu_{it} \tag{5.5}$$

where np_{it} is the number of products produced by the firm. We have also multi-sector firms. so we modify the demand shifter q_{st} to account for a firm producing goods in more than one sector, and the sector level demand shifter becomes:

$$\sum_{s=1}^{S} s_{is} \beta_s q_{st} \tag{5.6}$$

where s_{is} is the share of sector s in total demand.

We will, in the same spirit of DL, decompose the demand shock in observable and unobservable components. In our case, we use the available product structure of sales data to obtain firm-level final goods tariffs as natural demand shifters to be used to control for the unobserved price effects. The average product tariff for each period is defined as a weighted sum of final goods tariffs (tf) across all products c that the firm produced across the sample period:[4]

$$tf_{it} = \sum_c a_{ic} tf_{ct}$$

where tf_{ct} is the ad valorem tariff of product c at period t, while a_{ic} is the average share of product c in firm i's sales across all sample years. We express demand shocks as:

$$\xi_{it} = \xi_j + \tau tf_{it} + \widetilde{\xi}_{it}$$

where j denotes a product and $\widetilde{\xi}_{it}$ is an unobservable i.i.d. firm specific demand shock.

The estimated equation would be as follows:

$$\widetilde{r}_{it} = \beta_{np} np_{it} + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_s q_{st} + \sum_{j \in J(i)} \delta_j D_{ij} + \tau tf_{it} + \omega^*_{it} + \eta_{it} \tag{5.7}$$

where $J(i)$ denotes the set of products produced by firm, D_{ij} are dummy variables taking the value 1 if firm i produces product j, and η_{it} adds idiosyncratic shocks to production ν_{it} and demand ξ^*_{it}. In what follows product dummies will be grouped as $\delta D = \sum_{j \in J(i)} \delta_j D_{ij}$.

Then we extend DL's framework to analyse input protection as well as final good protection effects on productivity. We consider two channels for input protection to affect firm's behaviour, input demand and a productivity effect. A relevant feature of our data is that each firm reports the value of materials purchased by product. This allows us to compute firm-specific input protection measures ti_{it}, obtained as simple averages of tariffs of all product categories included in each firm's input purchases throughout the sample period.

As DL we assume a standard Levinshon-Petrin input demand equation, according to which the choice of materials m_{it} depends on the firm's productivity level, capital stock, and demand variables including final goods protection, sector demand and product dummies. It is natural

[4]This implies to take as reference the average product mix throughout all the sample years. We do not investigate the effect of changes in protection on firm's product mix.

to include input protection ti_{it} as an additional argument of the input demand equation, thus assuming:

$$m_{it} = m_t\left(k_{it}, \omega_{it}, tf_{it}, ti_{it}, q_{st}, D\right) \tag{5.8}$$

DL shows that such input demand function is monotonically increasing in firm productivity under imperfect competition.[5]

As to the productivity channel, we extend DL's framework to assume that final goods and input trade protection affect productivity according to:

$$\omega_{it} = g_t(\omega_{it-1}, tf_{it-1}, ti_{it-1}) + \psi_{it} \tag{5.9}$$

Summing up, there are two channels for the impact of trade protection on productivity. By equation (9) changes in final goods and input protection affect productivity with a lag, probably via eliminating inefficiencies, cutting slack, and/or via access to better quality of wider variety of inputs, etc. At the same time, contemporaneous final goods and input protection affect prices as well as product and input demand. Protection becomes a state variable in the firm's dynamic problem.

Exogeneity of tariffs is crucial for the estimation of the effect of trade policy on productivity. We consider that, in the case of Uruguay, producers have no power over setting tariff levels. The signature of binding international treaties (Mercosur and World Trade Organization) significantly curtailed the ability of the Uruguayan government to provide discretionary protection to specific sectors. Given the relative bargaining powers of Mercosur partners, the common external tariff (CET) endogeneity is likely to be a problem for studies of large countries like Argentina and, fundamentally, Brazil, but not for the smallest members Paraguay and Uruguay, in which firms may have had little chance to influence the general convergence scheme. This conclusion can be drawn from Olarreaga and Soloaga (1998), an application of a Grossman and Helpman protection for sale model to the Mercosur CET, which shows that the customs union external tariff follows closely the Brazilian tariff structure. Governments in small developing countries also find difficult to provide favors in the form of high output tariffs because they are under the close scrutiny of their trade partners, as well as that of international organizations.[6]

The input demand equation can be inverted to obtain:

$$\omega_{it} = h_t(k_{it}, m_{it}, tf_{it}, ti_{it}, q_{st}, D) \tag{5.10}$$

This provides a first stage equation to be estimated:

$$\widetilde{r}_{it} = \beta_{np} np_{it} + \beta_l l_{it} + \phi(k_{it}, m_{it}, tf_{it}, ti_{it}, q_{st}, D) + \eta_{it} \tag{5.11}$$

where $\phi(\cdot) = \beta_k k_{it} + \beta_m m_{it} + \beta_s q_{st} + \tau tf_{it} + \delta D + h_t(\cdot)$. This is estimated non-parametrically by applying OLS to the former equation, where $\phi(k_{it}, i_{it}, t_{it})$ is defined to be the degree 3 polynomial:

[5]See De Loecker (2011), Appendix C.

[6]Political favors may also be granted to firms via non-tariff barriers. Though it would have been desirable to investigate the separate effects of tariff and non-tariff protection, to our knowledge there are no ad-valorem equivalent of non-tariff estimates for Uruguay before 2006 (see Kee, Nicita and Olarreaga (2009)).

$$\phi(k_{it}, m_{it}, tf_{it}, ti_{it}, q_{st}, D) = \beta_k k_{it} + \beta_m m_{it} + \beta_s q_{st} + \tau tf_{it} + \delta D +$$

$$\sum_{w=0}^{3}\sum_{u=0}^{3-w}\sum_{v=0}^{3-w-u}\sum_{z=0}^{3-w-u-v}\sum_{y=0}^{3-w-u-v-z} \lambda_{wuvzy} k_{it}^{w} m_{it}^{u} tf_{it}^{v} ti_{it}^{z} q_{st}^{y}$$

In the first stage only the coefficients on labour and number of products are identified. The capital, material, aggregate sector demand and output tariff coefficients cannot be identified since they are collinear with the polynomial. Following DL, we do not interact the product dummies with the rest of the variables in the polynomial.

Then we undertake the second estimation stage, based on the assumed process for productivity, $\omega_{it} = g_t(\omega_{it-1}, tf_{it-1}, ti_{it-1}) + \psi_{it}$. The assumed orthogonality between ψ_{it}, and the set of observable variables is used to construct the moment conditions to identify β_k, β_m, β_s and τ. But first we have to recover ω_{it}. We do that by using that for given values of β_k, β_m, β_s, τ and δ the firm-level productivity terms can be written as

$$\omega_{it+1} = \widehat{\phi}_{it+1} - \beta_k k_{it+1} - \beta_m m_{it+1} - \beta_s q_{st+1} - \tau tf_{it+1} - \delta D$$

In practice, $\widehat{\phi}_{it}$ is obtained by subtracting $\widehat{\beta}_l l_{it}$ and $\widehat{\beta}_{np} np_{it}$ from $\widehat{r}_{it}$. Starting from some value for β_k, β_m, β_s and τ, we compute ω_{it}. Then we regress ω_{it+1} on polynomials of degree J of ω_{it}, tf_{it} and ti_{it} to obtain the residuals of the following regression equation:

$$\omega_{it+1} = \sum_{j=0}^{J} \theta_j \omega_{it}^{j} + \sum_{j=0}^{J} \lambda_j tf_{it}^{j} + \sum_{j=0}^{J} \mu_j ti_{it}^{j} + \Psi_{it}(\beta_k, \beta_m, \beta_s, \tau)$$

We must rely on the following moment conditions to identify the remaining coefficients. Period t's capital stock is determined by previous period investment choice, and tariff affects productivity with a lag. In turn, the lags of aggregate demand and materials are not correlated to present period's error. Hence he coefficients on capital, materials, aggregate sector demand and output tariff are obtained using the sample counterpart of the moment conditions:

$$E = \left\{ \Psi_{it+1}(\beta_k, \beta_m, \beta_s, \tau) \begin{bmatrix} k_{it+1} \\ m_{it} \\ q_{st} \\ tf_{it+1} \end{bmatrix} \right\} = 0$$

We do not estimate parametrically the impact of input protection tf_{it+1} on materials demand, but our productivity estimates do control for such influence. In our empirical evaluation of the impact of protection in productivity, the central role is played by our productivity estimates:

$$\widehat{\omega}_{it} = \left(\widetilde{r}_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_m m_{it} - \widehat{\beta}_s q_{st} - \widehat{\beta}_k k_{it} - \widehat{\tau} t_{it}\right) \left(\frac{\widehat{\eta}_s}{1 + \widehat{\eta}_s}\right)$$

We will regress our corrected firm level productivity estimates on tariffs and controls to find out if the effect of tarfffs in such corrected measures remains after controlling for unobserved prices.

5.3. Data

5.3.1. Manufacturing

We use a 1997 constant price firm-level panel for the period 1988-2001, constructed using data from the National Statistics Institute (INE), which became available for research recently.

The Manufacturing Survey database of the INE includes a sample of firms with a detailed questionnaire on production, sales, input and factor usage. For 1988-1996 the data source for the panel was the *Encuesta Industrial Anual* (Annual Manufacturing Survey, EIA), which encompasses formal manufacturing firms.[7] For 1997-2001 the source was the *Encuesta de Actividad Economica* (Economic Activity Survey, EAE), which captures formal firms with 5 or more employees, including not only manufacturing but also several services sectors (although the panel for this study includes only manufacturing firms).[8]

The panel contains annual data on output (sales), intermediate inputs, labour, capital and other expenditures. Data were deflated using detailed price indices. For output and materials we computed firm-specific deflators by weighting the four-digit ISIC revision 3 price indices by the share of each sector in firm's sales and material input costs, respectively. The estimation of capital stock was carried out using the perpetual inventory method, taking as starting point assets' values of the first year available for each firm.[9]

This study is based on matching manufacturing product data with detailed item-level tariff databases. Manufacturing data include a "product sheet"that contains the value of each product of the firm, and an "input sheet"with the same information for firm's intermediate inputs. We match each product code in the manufacturing sample (based on ISIC) to the corresponding item in the trade HS classification. To construct the firm-specific protection measures we determine for each firm the set of four-digit HS classes that contains all products produced/used as inputs by the firm during the sample period. The specific relevant output and input tariffs for firm i in period t are computed as the simple average in period t of the tariffs for all four-digit HS classes that encompass all firm's output and input items, respectively, across all sample years.

5.3.2. Trade policy and tariff data

Along the 1990 decade Uruguay continued its long trade openness process, started in the 1970s. Significant developments took place in this period, including the Mercosur integration agreement and reciprocal (multilateral and preferential) and unilateral measures (see Vaillant, 2006). In the early 1990s a unilateral tariff reduction was enacted, lowering protection and tariff dispersion. Preferential liberalization advanced with the signature in 1991 of the Asuncion Treaty, which laid the foundations for Mercosur and established an intra-zone tariff reduction schedule.

[7] All manufacturing firms with 100 or more employees (compulsory range) were surveyed, while for the group of firms with a number of employees between 5 and 99 (random range) a probabilistic sample was drawn. For details, see Instituto Nacional de Estadistica (1988).

[8] For this period, the compulsory sampling range includes all firms with 50 or more employees. For details, see Instituto Nacional de Estadistica (1997).

[9] The surveys' asset stock information is only available for 1988, 1990 and 1997-2001. The decay rates follow Oulton and Srinivasan (2003), who replicate the values used by the U.S. Bureau of Economic Analysis (BEA).

A long list of excepted items was negotiated. The Ouro Preto protocol set in motion in 1994 the process of adoption of a Common External Tariff (CET) by all Mercosur members (Argentina, Brazil, Paraguay and Uruguay), also with exception lists. Additionally, in 1994 the Uruguay Round Agreements were ratified by the Uruguayan parliament. Large macroeconomic changes also characterize the period. Vast restructuring took place in manufacturing, leading to large scale labour and capital reallocation.[10]

We use a detailed tariff database compiled by the Secretaria del Mercosur for 1991-2004. It includes most-favoured-nation (MFN) tariffs by eight-digit trade classification (ALADI for 1991-1994 and Mercosur for 1995-2004), a six-digit HS classification common to both periods, and the ISIC four-digit code. It also includes bilateral residual tariffs by item with all three Mercosur partners in 1991-1994, and the (common) intra-zone tariffs between 1995 and 2004. For 1988-1990 we use data from ALADI, at a four-digit level HS classification.

The general evolution of Uruguay's trade policy between 1988 and 2001 is shown by the falling path of its MFN tariffs shown in Table 1. We construct our yearly statistics using four-digit HS class averages. We also present the standard deviation within four-digit classes and the number of HS items per year.

Table 1: Uruguayan trade policy Indicators 1988-2001

year	MFN tariffs across 4-digit averages			Number of HS items
	mean	median	sd	
1988	27.80	28.00	11.79	7,691
1989	24.61	24.53	9.43	7,705
1990	28.12	28.33	7.96	7,730
1991	21.72	21.67	7.15	6,522
1992	18.20	18.17	5.01	6,522
1993	18.20	18.17	5.01	6,522
1994	14.69	15.31	5.00	6,522
1995	10.84	10.67	6.61	9,099
1996	10.77	10.34	6.43	9,112
1997	10.85	10.40	6.14	9,306
1998	13.23	13.00	6.39	9,346
1999	13.28	13.00	6.26	9,376
2000	13.40	13.00	6.15	9,391
2001	13.13	12.50	5.93	9,414

Source: Mercosur database

We observe average tariffs falling and its dispersion reducing along the period. The downward trend of tariffs reverses in 1998 due to a transitory increase in CET agreed by Mercosur members[11]. The variation in the number of HS items is explained by changes in the trade classification system (periodic revisions of the classification system introduce new items, expand

[10] In the early 1990s, a stabilization program based on an exchange rate anchor was undertaken, resulting in a significant reduction in inflation (from an annual rate of more than 100 percent in 1990 to around 5 percent ten years later) and a considerable real appreciation of the national currency (the peso).

[11] The transitory increase, applied between 1998 and 2003 to most products, implied an addition to CET of 3 % in 1998-2000, 2.5 % in 2001 and 1.5 % in 2002-2003.

some categories into more detailed sets with a larger number of them and collapse some others into broader categories with less items).

Exceptions and convergence to intra-zone zero tariffs are captured by the evolution of Uruguay's bilateral residual (over MFN) tariffs with its largest neighbours, Argentina and Brazil (see Table 2). It can also be observed a very high correlation between both average residual tariffs.

Table 2: Uruguayan bilateral residual tariffs
with respect to Argentina and Brazil
across 6-digit HS classes

	With Argentina		With Brazil		
Year	mean	median	mean	median	Correlation
1991	12.42	10.60	12.70	10.60	0.916
1992	8.81	6.63	9.03	6.63	0.945
1993	6.96	4.25	7.10	4.25	0.975
1994	3.74	1.65	3.76	1.65	0.994
1995	2.69	0.00	2.69	0.00	1.000
1996	2.51	0.00	2.51	0.00	1.000
1997	1.93	0.00	1.93	0.00	1.000
1998	1.28	0.00	1.28	0.00	1.000
1999	0.69	0.00	0.69	0.00	1.000
2000	0.01	0.00	0.01	0.00	1.000
2001	0.01	0.00	0.01	0.00	1.000

Source: Mercosur database

To adequately capture the relevant product and input neighbourhood we determine for each firm the set of four-digit HS classes that contain all the goods produced (used as inputs) by the firm throughout the sample period. Thus, each firm's product set is fixed over the period 1988-2001 in order to calculate firm-specific average protection. The specific relevant tariff for firm i in period t is the simple average in period t of the tariffs for the four-digit HS classes that encompass all items produced (used as input) by the firm across all sample years.

In Table 3 we provide descriptive statistics of MFN output and input tariff rates averaged across firms. We observe that input tariffs were along the period lower than output tariffs, with an average correlation of 0.6 between both firm-level tariffs.

Table 3: Output and input MFN tariffs
Firm-level averages

Year	Output tariff	Input tariff	Correlation coefficient
1988	31.82	26.93	0.52
1989	27.72	23.71	0.51
1990	30.66	27.38	0.51
1991	24.67	21.19	0.55
1992	20.27	17.86	0.56
1993	20.12	17.79	0.56
1994	16.67	14.23	0.53
1995	13.76	11.09	0.60
1996	13.61	10.85	0.62
1997	13.71	10.79	0.63
1998	15.99	12.95	0.63
1999	16.13	12.99	0.64
2000	16.19	13.07	0.63
2001	15.70	12.50	0.64

Source: INE manufacturing database; Mercosur trade database

In summary, capturing the political economic features of trade policy determination, it is always the case that average protection measured at firm level is higher than averages over the complete set of trade classification items (see tables 1 and 3). Comparison of the evolution of trade protection measures with respect to Uruguay's neighbours and the rest of the world shows distinct periods of trade policy (see tables 1 and 2). First, before 1995, both protection *vis a vis* the region and the rest of the world were falling ("open regionalism"), hence preferences for Brazil and Argentina did not change significantly. Between 1995 and 2000, convergence to the CET led MFN tariff to remain fairly constant or even increase, while the residual bilateral tariffs fell sharply, hence bilateral preferences increased considerably[12]. In the final period in our data -after 2000- intrazone tariffs are zero, while the action in the CET (MFN tariff) is little.

5.4. Production function estimates

Our estimation approach is an adjusted two-stage procedure in which unobserved prices and demand shocks are controlled for. Thus, it allows for a separate identification of the productivity and demand effects of changes in trade protection. Table 4 presents the preliminary results of our production function (first stage) estimates. Along with the DL-type corrected Levinsohn-Petrin method (columns 4 and 5), we undertook a standard Levinsohn-Petrin estimation (column 3), as well as OLS (column 1) and Olley-Pakes (column 2) estimations. As expected, in the OLS case the estimated coefficient on labour is higher and that on capital smaller than those obtained with the Olley-Pakes estimation technique, which corrects for the simultaneity bias. Our standard Levinsohn-Petrin estimation, however, does not show this bias correction of capital's coefficient.

[12]This broadly corresponds to the schedule negotiated in Ouro Preto in 1994.

When, in addition, we address the omitted price effect following DL's approach, we obtain higher coefficients on the three input variables (labour, materials and capital), relative to the standard Levinsohn-Petrin estimation. Since the omitted price variable biases inputs' estimates downward, this last result is exactly what would be expected.

Table 4: Production function estimates

	(1)	(2)	(3)	(4)	(5)
Coefficient on	OLS	Olley-Pakes	Standard LP	Corrected LP 1	Corrected LP 2
Labour	0.380	0.328	0.365	0.384	0.384
	(0.0191)	(0.0185)	(0.0152)	(0.0153)	(0.0169)
Materials	0.521	0.508	0.587	0.706	0.701
	(0.0167)	(0.0178)	(0.1212)	(0.0730)	(0.0651)
Capital	0.150	0.191	0.024	0.088	0.089
	(0.0117)	(0.0357)	(0.0715)	(0.0525)	(0.149)
Output				0.242	0.269
				(0.1929)	(0.1224)
Observations	10,514	7,836	10,602	10,351	10,351

Robust standard errors in parentheses.
Source: Authors' elaboration

5.5. The impact of protection on productivity

Then in Table 5 we present the second step regressions of our productivity estimates on output and input tariffs and controls. Our results indicate that a reduction in output tariffs had a positive effect on Uruguayan manufacturing firms' productivity over the period 1988-2001: a fall in final goods tariffs of 10 percentage points would have increased productivity by around 10 percent (see columns 2 and 3).

Table 5: Fixed effects firm-level regressions on firm-specific MFN tariffs 1988-2001

	(1) Standard LP	(2) Corrected LP 1	(3) Corrected LP 2
MFN output tariff	-0.434***	-1.025***	-0.965***
	(0.125)	(0.151)	(0.151)
MFN input tariff	0.293*	0.418**	0.431**
	(0.163)	(0.199)	(0.200)
Import status (IS)	-0.0372**	-0.0512**	-0.0514**
	(0.0171)	(0.0213)	(0.0214)
IS*MFN input tariff	-0.0743	-0.0789	-0.0802
	(0.0840)	(0.103)	(0.104)
Export share	-0.0976***	-0.115**	-0.112**
	(0.0360)	(0.0449)	(0.0450)
Size (log real sales)	0.179***	-0.00792	-0.00688
	(0.00744)	(0.00888)	(0.00890)
Value added/gross output	1.005***	1.172***	1.160***
	(0.0541)	(0.0631)	(0.0626)
Herfindhal index	0.177***	0.342***	0.353***
	(0.0443)	(0.0574)	(0.0586)
Time dummies	yes	yes	yes
Sector dummies	yes	yes	yes
Observations	10,261	10,256	10,256

Robust standard errors in parentheses
*** $p < 0{,}01$, ** $p < 0{,}05$, * $p < 0{,}1$
Source: Authors' elaboration

In contrast, the effect of lower input tariffs would have been negative: a reduction in input tariffs of 10 percentage points would have brought about a nearly 4 percent decrease in productivity. This last result needs to be further investigated, due to the aforementioned potential dual effect of reduced input protection. Higher input protection being associated with higher total factor productivity can be related to Corden (1971)'s argument on effective protection: lower input tariffs could increase effective protection, and incentives for the firms to shift to more efficient techniques be reduced. Then it can be interesting to include as a regressor some indicator of effective protection such as the effective rate of protection erp_{it}, given by $erp_{it} = (tp_{it} - a_{it}ti_{it})/(1 - a_{it})$, where a_{it} is the ratio of inputs to output for firm i at period t.

Differently from DL, we do not obtain smaller tariff effects on productivity once controlling for prices, than those obtained with the standard Levinsohn-Petrin productivity estimates. When ignoring the price effect, the impact of lower tariffs is smaller than when this effect is controlled for in the estimation of firms' productivity (see column 1).

5.6. Conclusions

We have intended to refine the analysis of the effect of trade protection on productivity, by performing a production function estimation that corrects for the impact of both endogenous production factor choices and unobserved demand shocks that influence the firm's input and product demands. Our results seem to reaffirm the conclusion previously obtained in Casacuberta and Zaclicever (2015), for a different sample period, using a traditional two-stage approach that ignores the unobserved price effects. There is a significant impact of protection as measured by MFN tariffs on Uruguayan manufacturing firm's TFP. Output tariff reductions enhance productivity, while we find the opposite for input tariffs (i.e., tariff reductions have a significant negative effect on TFP).

There are some directions for further research that can be followed based on the approach developed in this paper and the results obtained so far. Apart from the evaluation of the effective protection effect, for comparison purposes, a direct approach estimation can also be pursued. In addition, it might be interesting to consider the firm-specific protection measures used in this paper along with the replication of the usual studies based on sector-level tariff averages. We can also extend the analysis to assess the impact of residual bilateral tariffs with Uruguay's large Mercosur partners (i.e., Argentina and Brazil).

References

[1] Amiti, M. and Konings, J. (2007), "Trade Liberalization, intermediate inputs, and productivity: Evidence from Indonesia". *American Economic Review* Vol. 97 (5).

[2] Bernard, A., Jensen, B. and Schott, P. (2006), "Trade costs, firms and productivity". *Journal of Monetary Economics* 53: 917-937.

[3] Casacuberta, C., Fachola, G. and Gandelman, N. (2004), "The Impact of trade liberalization on employment, capital and productivity dynamics: Evidence from the Uruguayan manufacturing sector". *Journal of Policy Reform* 7(4): 225-248.

[4] Casacuberta, C., and Zaclicever, D. (2015), "The effect of trade protection in productivity in Uruguay ". *Documento de trabajo. dECON, FCS, Uruguay* No.2/2015.

[5] Corden, M. (1971), *The theory of protection.* Oxford University Press.

[6] Fernandes, A.M. (2007), "Trade policy, trade volumes and plant-level productivity in Colombian manufacturing industries". *Journal of International Economics* 71 (1): 52-71.

[7] Instituto Nacional de Estadística (1988), III Censo Económico Nacional Segunda Fase. Industria Manufacturera.

[8] Instituto Nacional de Estadística (1997), Metodología: Encuesta de Actividad Económica.

[9] Kee, H.L., Nicita, A. and Olarreaga, M. (2009), "Estimating trade restrictiveness indices". *The Economic Journal* 119: 1-28.

[10] Klette, T.J. and Griliches, Z. (1996), "The inconsistency of common scale estimators when output prices are unobserved and endogenous". *Journal of Applied Econometrics* 11: 343-361.

[11] Levinsohn, J. and Petrin, A. (2003), "Estimating production functions using inputs to control for unobservables". *Review of Economic Studies* 70: 317-341.

[12] Lopez-Cordova, E. and Mesquita, M. (2003), "Regional integration and productivity: The experiences of Brazil and Mexico". Working Paper 14, INTAL-ITD-STA.

[13] Melitz, M.J. (2003), "The impact of trade on intra-industry reallocations and aggregate industry productivity". *Econometrica* 71 (6): 1695-1725.

[14] Muendler, M.A. (2004), "Trade, technology and productivity: A study of Brazilian manufacturers 1986-1998". Department of Economics, University of California, San Diego (UCSD), Paper 2004-06.

[15] Olarreaga, M. and Soloaga, I. (1998), "Endogenous trade protection in Mercosur". *World Bank Economic Review.*

[16] Olley, G. and Pakes, A. (1996), "The dynamics of productivity in the telecommunications equipment industry". *Econometrica* 64: 1263-1297.

[17] Oulton, N. and Srinivasan, S. (2003), "Capital stocks, capital services, and depreciation: an integrated framework". Working Paper No. 192, Bank of England.

[18] Pavcnik, N. (2002), "Trade liberalization, exit and productivity improvements: evidence from Chilean plants". *Review of Economic Studies* 69 (1): 245-276.

[19] Trefler, D. (2004), "The long and short of the Canada-U.S. free trade agreement." *American Economic Review* 94 (4): 870-895.

[20] Vaillant, M. (2006), "Determinants of trade liberalization strategies in Uruguay". Chapter 3 in Bouzas, R. (ed.), *Domestic determinants of national trade strategies. A comparative analysis of Mercosur countries, Mexico and Chile*. Chaire Mercosur de Sciences Po.

6 Conclusiones

En este capítulo se presenta una síntesis de las conclusiones de la tesis, incluyendo un comentario sobre los resultados para cada trabajo, las limitaciones que se verifican y posibles direcciones de un futuro trabajo de investigación.

Con respecto al primer trabajo, se analizó una variante de los modelos de comercio con empresas heterogéneas. El modelo introduce una restricción de exportaciones que está basada en una restricción financiera (aunque es compatible con otro tipo de mecanismos, por ejemplo el que países vecinos en situación de devaluación establezcan barreras no arancelarias coincidentes con la devaluación en el país objeto de análisis). El funcionamiento del modelo es satisfactorio en la medida que las simulaciones muestran que aún después de dar cuenta del conjunto de repercusiones en la actividad de las demás empresas, en equilibrio se produce un efecto en los precios y en las cantidades consistente con el *pass-through* incompleto que se observa en los datos, así como con la correlación negativa entre cambios en la fracción de exportaciones en las ventas y cambios en el precio relativo de las exportaciones.

Sin embargo, resulta interesante poner a prueba distintas decisiones acerca de cómo construir el modelo, en el sentido de que si bien el conjunto de los supuestos actuales es efectivo en producir resultados cualitativos que se adaptan a la explicación buscada, no es necesariamente cierto que se ha logrado el conjunto mínimo de supuestos requerido, con lo que podría lograrse mejorar el modelo y volverlo más general. Más aún, podría simplificarse su formulación analítica y volverse más tratable.

A diferencia de lo habitual, es decir que las empresas difieran únicamente en la dimensión de la productividad, aquí se introdujo una dimensión adicional, por lo que las empresas difieren también en el precio internacional que enfrentan. Esto se refiere a las definiciones conceptuales que subyacen a la arquitectura del modelo. En el modelo de Melitz (2003) por ejemplo, en un sector dado existe un continuo de variedades, cada una de las cuales es percibida como diferente. El conjunto de las variedades producidas por la o las economías fuera de la doméstica también son un conjunto continuo, aunque es otro conjunto. La idea de una "variedad" en Melitz está asociada a una determinada productividad, y este autor señala que puede entenderse de dos maneras, como que la variedad es la misma pero es producida más eficientemente, o como que se produce una variedad diferente con la misma productividad.

En el caso de este modelo, se introduce una dimensión extra, que es el precio de exportación. Las empresas se ordenan de acuerdo al precio que reciben. Este precio entonces podría también verse como un indicador de diferenciación de las variedades, por ejemplo calidad subyacente, etc. El modelo que se presenta en esta tesis establece que el número de variedades producidas localmente, comparado con el exterior es pequeño y poco diversificado, por lo que quizás el supuesto de un continuo de infinitas posibilidades podría ser exagerado. Por lo tanto podría resultar interesantes estudiar cómo funciona este modelo con una estructura oligopólica consistente en un conjunto finito de empresas en lugar de un continuo infinito.

También es interesante considerar el alcance del supuesto de que las empresas son tomadoras de precios en el mercado de exportación. En el caso del modelo de Melitz, puede considerarse una limitación el que considerar una estructura de demanda a la Dixit y Stiglitz (1977) produce un markup fijo. En este modelo se lleva esto al extremo, ya que que en mercado competitivo no existe markup. Demidova y Rodríguez Clare (2013) toman un camino intermedio en el cual existe una pendiente negativa de la curva de demanda, pero el resultado de la actividad de las empresas domésticas no puede afectar lo que ocurra en el resto del mundo, lo cual constituye su manera de concebir una economía pequeña. Una dirección interesante en que explorar este modelo es estudiar en qué medida se necesita que exista esta condición de empresa exportadora tomadora de precios.

Además el hecho de considerar mercados competitivos agrega complicación analítica al modelo. El hecho de que empresa pueda vender al precio de exportación dado toda la cantidad que desee deja indeterminada la cantidad, a menos que existe un coste marginal creciente. Esto complica el modelo con respecto por ejemplo a Melitz 2003, que introduce una tecnología muy simple de costo marginal constante, lo que se revela muy útil cuando se trata de agregar los resultados y encontrar el equilibrio de mercado.

De acuerdo al modelo, aquellas empresas que se encuentran sin restricciones son las de altas productividad y con "buenos" precios de exportación, con lo que son las que producen más, tienen más empleo y más ventas. Esto se relaciona con el hecho observado de que en las reactivaciones de las exportaciones que siguen a las devaluaciones son unas pocas grandes empresas las que explican el grueso de la reactivación. Esto se relaciona también con que no se ha hecho ningún supuesto acerca de la distribución en la población de empresas de las productividades y precios, más allá de densidades uniformes independientes. Supuestos diferentes sobre la distribución conjunta de precios y productividades podría genera interesantes variaciones cualitativas de los resultados.

Finalmente se puede comentar que la simulación resulta precaria aún. En la etapa actual solamente demuestra que que el modelo es capaz de producir -para cierta configuración de los parámetros- resultados cualitativamente compatibles con los que el análisis sugiere. Sin embargo, y dado que no se provee soluciones cerradas analíticas, es necesario refinar la simulación numérica. En lo cuantitativo, debe explicitarse y fundamentarse la elección de los valores de los parámetros, y relacionar los rangos de las variables con el objetivo de replicar los valores observados de los momentos de las variables relevantes (incluyendo las covarianzas) de acuerdo a los datos.

El segundo trabajo aborda la estimación econométrica de la respuesta exportadora de las empresas un contexto de cambios en el tipo de cambio. Esto está relacionado con el modelo desarrollado en el trabajo anteriormente mencionado. Se intenta fundar el análisis de los datos en el mecanismo microeconómico de la maximización de beneficios de las empresas en cada una las situaciones posibles: salida del mercado, no exportador, exportador restringido, exportador sin restricciones.

En el contexto de grandes cambios de precios relativos, los temas relacionados con la medición son importantes. Con respecto al lado izqiuerdo de las ecuaciones, en un caso tenemos una variable dicotómica que no cambia con la elección del año base. En el otro tenemos una variable a precios constantes donde las cantidades en la fracción de exportaciones o *export share* evolucionan en forma disímil. En el trabajo se muestra evidencia acerca de cómo la elección del año base tiene un impacto en algunas medidas descriptivas como los diferenciales de productividad entre exportadores y no exportadores.

En la estimación del impacto del tipo de cambio y características estructurales de las empresas en la probabilidad de exportar y en la especialización exportadora, algunos de los impactos que se obtienen son compatibles con la visión que elabora el modelo. Sin embargo no se ha logrado una estimación estructural convincente. La estimación econométrica debería ser capaz de limpiar la estimación del efecto de la influencia de la elección de precios de referencia. En esta dirección se debería seguir avanzando. Es claro que en la estimación de la productividad total de factores los precios están a ambos lados de la ecuación. La peculiaridad se encuentra en que en estos datos evolucionan de manera marcadamente diferente. Una variante interesante podría ser incorporar precios de empresa (en lugar de índices específicos de empresa basados en precios de sector) en el análisis econométrico.

En el último de los trabajos se ha intentado extender el análisis del impacto de la protección en la productividad total de factores, para incluir no solamente la protección del producto sino también la de los insumos. La contribución es metodológica. El trabajo de De Loecker (2011) que es antecedente de éste realiza una modificación de los métodos de estimación de la función de producción basados en variable *proxy* para controlar por los precios no observados y shocks de demanda y estudiar el impacto de la protección a los bienes finales. En el trabajo, se adapta la metodología para incluir también los insumos. Como los insumos son una variable proxy, resulta natural modelar los mecanismos por los que la protección de insumos afecta la productividad. Los efectos obtenidos son de signo contrario, en el sentido de que reducciones de aranceles al producto incrementan la productividad, mientras que reducciones a la protección de insumos disminuyen la productividad.

En cuanto a direcciones en las que extender el trabajo de investigación, uno de los mecanismos por los que se ha argumentado que opera la protección de insumos es a través del acceso a una canasta más diversa o de mayor calidad. También se ha relacionado la liberalización de la protección de los insumo con la diversificación e introducción de variedades nuevas de productos. Sería interesante relacionar estas dimensiones de la exposición internacional de las empresas.

También tiene sentido comparar el desempeño de las medidas específicas a la empresa usadas en este trabajo con las medidas usuales de promedio de aranceles de sector. Asimismo, se podría evaluar además de los aranceles de nación más favorecida, el impacto de los aranceles residuales con los vecinos del Mecosur.