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ARTÍCULOS

Efecto cobra en México: gasto social y pobreza, 2008-2018*

Cobra effect in Mexico: social expenditure and poverty, 2008-2018

Eduardo Loría**
Eduardo Martínez***

Resumen

Examinamos la eficiencia de las transferencias monetarias en la pobreza extrema multidimensional en los estados de México durante el periodo 2008-2018. Estimamos modelos econométricos con datos de panel por MCO y MCO2E y con datos de sección cruzada con GMM que blindan contra la endogeneidad de los determinantes de la pobreza. Probamos que existen incentivos perversos que han generado que las transferencias perpetúen la pobreza en los estados menos desarrollados. Los homicidios y la informalidad laboral también la han perpetuado. La productividad laboral agrícola, el crecimiento económico, la orientación productiva de exportación y un mejor Estado de Derecho la reducen.

Palabras clave: *Pobreza extrema multidimensional, transferencias monetarias directas, incentivos perversos, Estado de Derecho, heterogeneidad estructural.*

Clasificación JEL: *P36.*

Abstract

We examine the efficiency of the cash transfers on multidimensional extreme poverty in the states of Mexico for 2008-2018. We estimate econometric models

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** Centro de Modelística y Pronósticos Económicos (CEMPE), Facultad de Economía, UNAM, Edificio B, 3er. piso, cubículo 305, Circuito Interior, Ciudad Universitaria, México, Ciudad de México, CP: 04510. E-mail: eduardol@unam.mx.

*** Centro de Modelística y Pronósticos Económicos (CEMPE), Facultad de Economía, UNAM. E-mail: l.aleve@hotmail.com

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with panel data with OLS and 2SLS and with cross-section data with GMM that shield against endogeneity of the determinants of poverty. We prove that there are perverse incentives that have caused that transfers perpetuate poverty in the less developed states. Homicides and informal employment have perpetuated it. Agricultural labor productivity, economic growth, productive export orientation, and a better Rule of Law reduce it.

Key words: *Extreme multidimensional poverty, direct monetary transfers, perverse incentives, Rule of Law, structural heterogeneity.*

JEL Classification: *P36.*

No basta con hacer el bien; hay que hacerlo bien
Denis Diderot

El infierno está empedrado de buenas intenciones
Bernardo de Claraval

1. Introducción

Los esfuerzos gubernamentales por reducir la pobreza se institucionalizaron y se focalizaron desde comienzos de los años noventa del siglo pasado. La *Iniciativa 20/20* de 1995 buscaba disminuir el porcentaje de la población en pobreza extrema por ingresos para el año 2000 (ONU, 1995) en términos de aquellos que "(…) no disponen de los recursos para satisfacer sus necesidades básicas de alimentación [que equivalen a US$ 1,9 diarios, ONU, 2010: 24]". En el 2000, la ONU fijó como su *Primer Objetivo de Desarrollo del Milenio* reducir a la mitad la pobreza extrema por ingresos en 2015 respecto de 1990. Muchos países, incluido México, lo lograron (ONU, 2015a), por lo que el *Primer Objetivo del Desarrollo Sostenible* de la ONU (2015b) era erradicarla en 2030[1].

La ONU fijó esta meta ambiciosa debido a que la pobreza extrema por ingresos es muy susceptible de sufrir grandes variaciones cuando el gobierno transfiere recursos monetarios. Basta que los ingresos personales sean mayores a US$ 1,9 diarios para que automáticamente salgan de esa condición.

Sin embargo, Banerjee *et al*. (2015) demuestran que las transferencias monetarias a los pobres solo estabilizan su consumo de alimentos y no necesariamente resuelven sus carencias estructurales. Su propuesta de política consiste en delegar este gasto al último nivel de importancia en los programas sociales a cambio

[1] Que ahora será sumamente difícil de lograr a causa de la *Coronacrisis*, al grado de que podrían perderse 30 años de avances (CONEVAL, 2020b).

de impulsar empleos productivos y autosustentables en el sector primario, que sí pueden tener resultados de alto aliento.

La medición expresa de la pobreza por ingresos en México es reciente (desde 1992); sin embargo, desde 2008 el CONEVAL (2020c) mide bienalmente la pobreza extrema multidimensional (PEM) y la define como el porcentaje de la población que además de no contar con ingresos suficientes para satisfacer sus necesidades básicas alimentarias tiene tres o más carencias sociales de seis posibles[2]. Por tanto es un indicador más integral de la pobreza que no necesariamente disminuye a mayores transferencias monetarias del gobierno.

En línea con los objetivos del milenio, el gobierno mexicano ha destinado recursos específicos (etiquetados) para atender la pobreza desde 1992 (Loría, 2020a). No obstante, lo ha hecho bajo un régimen de centralización fiscal donde asigna recursos a cada estado del país en progresividad a sus necesidades, "castigando" presupuestalmente a los exitosos (que reducen la pobreza) y "premiando" a los que la mantienen o la incrementan (CEFP, 2009: 30).

De acuerdo con Careaga y Weingast (2000), Fisman y Gatti (2000, 2002) y Ramones y Prudencio (2014), en un sistema de recursos públicos centralizados tienden a generarse incentivos perversos en todos los involucrados de la política social. Por un lado, los políticos, administradores y burócratas tienen incentivos perversos de apropiarse los recursos para beneficio propio (corrupción), y los beneficiarios de la política social, ante la falta de oportunidades de empleo y superación personal, eligen racionalmente mantener su condición socioeconómica para así continuar recibiendo los apoyos monetarios del gobierno.

Quizá el caso más conocido de incentivos perversos en la política social, y por ello Siebert (2001) acuñó el término *efecto cobra,* ocurrió durante el periodo colonial en Nueva Delhi (1858-1947), cuando muchas comunidades pobres sufrieron epidemias de cobras y el gobierno británico aplicó programas de transferencias monetarias para que los habitantes las capturaran, pero no contemplaron que la epidemia se volvería deseable (rentable) para los beneficiarios, quienes comenzaron a criar los reptiles para recibir la ayuda oficial. En el corto plazo la epidemia disminuyó y finalizó el programa, por lo que después la población liberó a las crías, agravando así el problema inicial. Lo mismo ocurrió con la epidemia de ratas en Hanói (Vietnam) bajo el gobierno colonial francés (Vann, 2003).

Al estilo del *efecto* cobra, nuestra hipótesis plantea que las transferencias monetarias del gobierno mexicano a las familias pobres (TMGP) perpetúan la pobreza extrema multidimensional (PEM) durante el periodo 2008-2018 solamente en los estados más rezagados económica, social e institucionalmente de México, por lo que es plausible sugerir que en esos estados se ha generado ese efecto y viven en una trampa de pobreza.

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[2] Acceso a: a) educación, b) salud, c) seguridad social, d) calidad y espacios de la vivienda, e) servicios básicos en el hogar y f) alimentación.

Justificamos nuestro análisis a nivel de los estados a la luz de la hipótesis de heterogeneidad estructural en México de CEPAL (2016). Este enfoque teórico fue acuñado por Pinto (1970) y señala que existen diferencias o brechas estructurales en materia económica, social e institucional entre los estados de un país. De acuerdo con CEPAL (2016), las brechas estructurales más grandes en México se reflejan en: a) la contribución sectorial del PIB y del empleo, b) perfiles de producción orientados a la exportación, c) calidad del mercado laboral (informalidad del empleo y condiciones de ocupación), y d) la fortaleza de las instituciones que proveen de incentivos correctos a los individuos y empresas.

La hipótesis de heterogeneidad estructural radica en que estas brechas generan asimetrías de productividad laboral intersectorial y entre estados. La conclusión principal de CEPAL (2016: 28) es que el lento crecimiento económico de los estados está asociado con la baja productividad sectorial, que se relaciona con la existencia de estas brechas, con lo que es posible explicar dinámicas heterogéneas en desarrollo y, por tanto, en pobreza.

En concordancia con esa hipótesis, analizamos 3 conjuntos amplios de variables estatales que la aproximan. El primero incorpora desempeños económicos como el PIB real y su tasa de crecimiento, el ingreso laboral *per cápita*, el PIB *per cápita*, la productividad media laboral sectorial y el coeficiente de exportaciones totales a producto. Un segundo conjunto incluye variables sociales vinculadas al mercado laboral (tasa de condiciones críticas de ocupación y de informalidad laboral). Por último, aproximamos el factor institucional (fortaleza de las instituciones) con el Índice de Estado de Derecho de *World Justice Project* del año 2018 y las tasas de incidencia delictiva (homicidios dolosos, extorsiones y secuestros)[3]. Ver definiciones de todas estas variables en la Tabla 1A.

Con base en estas variables, Loría *et al.* (2020b) agrupan a 30 entidades federativas de México en dos: G1 integrado por 22 estados con mayor desarrollo (económico, social e institucional) y en donde se generan estimaciones robustas de la Ley de Okun (1962), y G2 (8 restantes) que por su atraso no reportan estimaciones congruentes ni significativas. La inoperatividad de esta ley, que es una de las regularidades más confiables de la macroeconomía (Tobin, 1980), les permite sugerir que G2 podría estar inmerso en una trampa de pobreza que tiende a retroalimentarse por la generación de externalidades como corrupción, violencia social, informalidad, precariedad laboral y bajo desarrollo.

Adoptamos esa agrupación y demostramos que una externalidad adicional en G2 es la operación del *efecto cobra*, que no ocurre en G1. No usamos las regionalizaciones de CONEVAL (2014), INEGI (1978) o el Banco de México (2020) debido a que cada una se integra por varios estados o entidades no necesariamente homogéneos para nuestros propósitos ni congruentes con sus

[3] La construcción metodológica del Índice de Estado de Derecho (WJP, 2018) aproxima mucho al grado de corrupción en cada estado, por lo que podemos vincularla con la generación de incentivos perversos y también es un indicador que aproxima a otras condiciones sociales como orden, seguridad, justicia y derechos humanos.

diferencias (brechas) estructurales. Cada una de ellas responde a sus objetivos institucionales particulares y no al de este trabajo.

Nuestros resultados indican que PEM disminuyó en 30 entidades federativas por razones diversas. En G1 se atribuye en gran parte al crecimiento económico, mientras que en G2 fue por la productividad laboral del sector primario. TMGP apoyó en la reducción de PEM en G1, pero en G2 la perpetuó. También demostramos que existen mecanismos adicionales (exógenos a los programas sociales) que explican la pobreza extrema multidimensional, como el rezago de los mercados laborales y el grado de especialización tecnológica que puede aproximarse con el coeficiente de exportaciones a producto. También demostramos la importancia central de la violencia (tasa de homicidios dolosos, que utilizamos como *proxy* del Estado de Derecho)[4].

Estos resultados derivan de estimaciones econométricas robustas con datos de panel con Efectos Fijos que atienden la heterogeneidad en G1 y a nivel nacional, y por Efectos Aleatorios y Efectos *Pooled* en G2 que captura su homogeneidad en términos de su atraso en desarrollo.

Es muy común que exista endogeneidad al estudiar los determinantes de la pobreza (Anser *et al*., 2020; Ramones y Prudencio, 2014; Negin *et al*., 2010; Mauro, 1995), debido a que hay retroalimentaciones entre ellas, por lo que estimamos modelos de panel con variables instrumentales por Mínimos Cuadrados Ordinarios en 2 Etapas (MCO2E), que resuelven este problema y generan estimadores eficientes (Donou-Adonsou y Sylwester, 2016; Imai *et al*., 2014). Por último, estimamos la importancia del Índice de Estado de Derecho –que aproximamos con un índice *ad hoc* publicado por *World Justice Project* en 2018– en la reducción de la pobreza, que solo fue posible hacer con datos de sección cruzada que también atienden endogeneidades con GMM (Hansen, 1982).

Nuestro trabajo contribuye a la literatura en muchos aspectos debido a que: a) en México no existen series oficiales disponibles e integradas de transferencias a los pobres ni a nivel nacional ni por estados, por lo que las construimos expresamente con la metodología descrita en la Tabla 1A; b) demostramos econométricamente que esta variable arroja resultados con sentido económico y totalmente congruentes con la hipótesis del *efecto cobra*; c) a diferencia de otros trabajos respecto de pobreza (Banerjee *et al*., 2015) que aplican Pruebas Controladas Aleatorizadas (RCT), las secciones transversales de nuestro panel refieren a estados (no a personas) y generan resultados complementarios, nunca excluyentes, con otros autores que utilizan diferentes enfoques teóricos y estas o las mismas técnicas que nosotros[5]; d) construimos una base de datos robusta que prueba la hipótesis de heterogeneidad estructural de los estados del país y

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4 Es la variable delictiva que más refleja el rompimiento del tejido social (Salama, 2013), debilita la cohesión social y deprime la inversión privada, lo que reduce la actividad económica (Rizzo, 1979) y eleva la pobreza.

5 Mauro (1995); Gupta *et al*. (1998); Ramones y Prudencio (2014); Negin *et al*. (2010); Campos-Vázquez y Monroy-Gómez-Franco (2016); Hernández-Laos y Benítez-Lino (2014); Tirado-Alcaraz (2014).

que se muestra en Tabla 1, con la que pudimos hacer una adecuada agrupación (G1 y G2) que responde a nuestra hipótesis; y e) con base en nuestros resultados, identificamos políticas públicas (exógenas a los programas sociales) que podrían disminuir (o preservar) la pobreza no solo en México y en sus estados, sino también en otros países y regiones que presentan este problema.

Además de esta primera sección, en la segunda revisamos otros casos documentados de incentivos perversos; en la tercera revisamos la literatura y los aspectos teóricos. La sección cuatro presenta las regularidades empíricas de México. En la quinta presentamos los aspectos econométricos y en seguida discutimos y analizamos los resultados estadísticos. Por último, concluimos y hacemos comentarios finales y recomendaciones de política.

2. Incentivos perversos y realidad

Independientemente del grado de desarrollo del país de estudio, hay casos mundialmente famosos y documentados de políticas públicas que –al no considerar la elección racional de los participantes– hace que todos los participantes aprovechen los huecos burocráticos y las buenas intenciones de los programas para obtener beneficios sin actuar en favor de la política, perpetuando así el problema inicial, al estilo del *efecto cobra*.

Para Estados Unidos, está documentado *el caso de los Apalaches* donde el gobierno local daba apoyos monetarios a los padres cuyos hijos tuvieran deficiencias mentales, lo que los estimuló a mantenerlos iletrados y sin educación hasta los 18 años para aplicar en el programa (Douthat 2012).

En México, desde hace años, varios gobiernos estatales realizan múltiples transferencias monetarias a distintos grupos en condición de pobreza o de vulnerabilidad económica y social, como el apoyo a madres solteras jóvenes (SHCP, 2019) que, aunado a la baja educación sexual de los segmentos más pobres, puede incrementar los embarazos, así como ocurre en Chiapas, estado con mayor pobreza multidimensional de todo el país, en el que se ofrecen apoyos monetarios gubernamentales por hijo adicional (Peláez-Herreros, 2012). Quizá el programa federal más reciente impulsado con enormes recursos del gobierno federal actual (2018-2024) es *Jóvenes Construyendo el Futuro*, que otorga "becas" económicas directas a jóvenes sin trabajo y que no estudian (*ninis*), que opera con gran opacidad y a principios de 2021 ha mostrado notorios indicios de corrupción y uso clientelar de carácter electoral, a la vez que no parece atender su objetivo principal (Aveldaño *et al*., 2021a y 2021b).

En México hay otros ejemplos de resultados opuestos a los buscados por la política, como el programa *Hoy no circula* que buscaba reducir las altas emisiones de CO_2 en la Ciudad de México. El primer registro del programa aplicado a automovilistas fue en 1989, que pretendía disminuir las emisiones con base en reducciones del tránsito vehicular; sin embargo, llevó a la población a adquirir más automóviles (nuevos y viejos, aún más contaminantes) y se alcanzaron niveles récord de contaminación desde que se tienen registros (Ventura, 2020).

Actualmente el programa *Sembrando Vida* busca mejorar la calidad del aire con base en trasferencias monetarias a la población por cada árbol que siembren, fomentando así la tala de árboles maduros (Castillo, 2020).

Todos estos expedientes muestran que cuando los gobiernos desean resolver problemas sociales sin tomar en cuenta la elección racional de los involucrados fácilmente pueden generarse incentivos perversos que empeoran el problema inicial. Careaga y Weingast (2000) lo demuestran para los gobiernos estatales de México (1980-2000) y concluyen que la centralización de las políticas sociales conduce a corrupción o por lo menos a desviación de recursos, que afecta el crecimiento económico, el bienestar social y sacrifica el gasto público productivo, lo que tiende a generar un círculo vicioso de corrupción y pobreza.

La literatura que reporta resultados exitosos en la lucha contra la pobreza menciona que para evitar desviaciones e incentivos perversos se requiere impulsar aspectos laborales, de finanzas personales (Banerjee *et al*. 2015), educativos y de salud en la población objetivo (Saucedo-Delgado *et al*. 2018; Tirado-Alcaraz, 2014), que Mauro (1995, 1996, 1998, 2002) engloba en términos de incrementar el crecimiento económico y fortalecer las bases del Estado de Derecho (orden, seguridad y justicia), en lugar de dar asignaciones monetarias directas sin responsabilidades a cambio.

3. Revisión de literatura y aspectos teóricos

Los trabajos fundacionales de Rosenstein-Rodan (1943) y Nurkse (1953) plantean que existe una estrecha relación bidireccional entre crecimiento económico y pobreza. En fechas más recientes han sobresalido los trabajos de Azariadis y Stachurski (2005) y Deaton (2013), que plantean la hipótesis de trampa de pobreza en países (y regiones) con alto subdesarrollo y bajo crecimiento, circunstancia en donde el empleo tiende a ser precario, informal, poco productivo y con bajo valor agregado, por lo que las familias en pobreza limitan su ahorro e inversión (física y en capital humano), perpetuando así su lúgubre condición.

Azariadis y Stachurski (2005) demuestran que la pobreza genera diversas externalidades en el crecimiento económico porque limita la innovación y adopción de tecnologías más productivas, lo que provoca múltiples endogeneidades. De acuerdo con Mayer-Foulkes (2008) y Deaton (2013), algunas de las causas y consecuencias de la trampa de pobreza son desnutrición, enfermedades y deficiencias físicas e intelectuales que pueden ser crónicas e intergeneracionales, provocando también problemas psicológicos.

Hace 60 años Lewis (1959) reportaba evidencia de que en México se había generado una "cultura de la pobreza" (por factores socioculturales y psicológicos) muy enraizada en la población que podría perpetuarla. En el caso extremo, De Janvry y Sadoulet (2015) señalan que las familias en pobreza pueden incurrir en conductas violentas, disociativas y conformistas, que también perpetúan su condición.

Banerjee *et al*. (2015: 5) sugieren que la mejor alternativa para romper la trampa de pobreza es aplicar programas sociales específicos enfocados en las familias de las comunidades más pobres, frecuentemente ubicadas en zonas rurales, para transferirles "activos biológicos" (vacas, cerdos, corderos, entre otros) e instruirles en su manejo financiero y administrativo para crear las condiciones productivas-empresariales (nunca asistenciales) necesarias para que las familias logren incorporarse de mejor manera al mercado laboral mediante el autoempleo y vendiendo bienes y servicios que producen con esos activos, teniendo como efecto final la independización de los programas públicos.

Dos efectos adicionales de ese tipo de programas, que pueden erradicar la cultura de la pobreza –y que las políticas asistencialistas no hacen–, son: a) fomentar el ahorro de los beneficiarios para que sean así menos vulnerables ante desastres naturales o emergencias médicas (gastos catastróficos, Rodríguez-Oreggia *et al*., 2013), y b) el cambio psicológico y conductual. Banerjee *et al*. (2015: 14) señalan que "el programa funciona haciendo que los beneficiarios sientan que importan, que la sociedad se preocupa por ellos y que con esta ayuda inicial pueden tener mayor control sobre su bienestar actual y que, por lo tanto, su futuro puede ser mejor".

Los programas propuestos por Banerjee *et al.* (2015) solicitan el cumplimiento de dos requisitos cruciales que tratan de blindarlos de incentivos perversos: a) que el valor total de los activos no supere US$ 1.228 por hogar y b) que se dé seguimiento a las familias para constatar que los activos se estén empleando correctamente. Se busca evitar así que los vendan o que los utilicen para consumo propio. Si los beneficiarios cumplen con ello, se les transfieren recursos monetarios que no superan US$ 71 mensuales únicamente para estabilizar su consumo de alimentos en el corto plazo.

Una línea de investigación referente a la pobreza sugiere el uso de Pruebas Controladas Aleatorizadas, originaria del campo de la medicina, que parte de una muestra poblacional que se divide (aleatoriamente) en dos para aplicar tratamiento (política) a un grupo y evaluar si existe mejoría en el tiempo respecto de su situación inicial y respecto del otro grupo sin tratamiento (White *et al*., 2014). De acuerdo con Glennerster y Takavarashka (2018), esta técnica permite seguir en el tiempo los cambios en el comportamiento y en la situación socioeconómica de los beneficiarios de la política social.

Con base en RCT, Banerjee *et al.* (2015) aíslan el impacto de las transferencias monetarias, las transferencias de activos biológicos, el apoyo psicológico, la educación financiera y la provisión de atención médica a las familias pobres y demuestran que con estos apoyos los programas sociales logran independizar a los beneficiarios de los estímulos fiscales. Para el caso de México, Saucedo-Delgado *et al*. (2018) aplican RCT y demuestran que las transferencias condicionadas del programa *Prospera-Oportunidades* no incrementan el envío de niños a la escuela ni mejoran su atención médica, resultados contrarios al objetivo del programa y que contradicen los de Gertler (2004) y Schultz (2004), quienes usan esa misma técnica.

Es probable que esta discrepancia se deba a las deficiencias de la técnica RCT porque: a) no permite evaluar el impacto de políticas inobservables en el interior del programa, con lo que es imposible identificar otros modos de intervención del gobierno (Greene, 2012; White *et al*., 2014); b) no permite diferenciar el efecto entre entidades, como lo sugieren Saucedo-Delgado *et al.* (2018) al excluir a Campeche y Chiapas del análisis por tener alta pobreza, lo que no contrastan con sus desempeños económicos, sociales e institucionales[6], y c) incurren en sesgo por las familias a las que se les negó el acceso al programa (Glennerster y Takavarashka, 2018).

Como alternativa a RCT, Tirado-Alcaraz (2014) sugiere estimar modelos panel de efectos fijos y, con base en ello, prueba que esas transferencias no reducen la pobreza por ingresos, lo que está en línea con Saucedo-Delgado *et al*. (2018).

A pesar de las distinciones entre ambas técnicas y que ninguno de esos autores vincula las transferencias con la pobreza multidimensional ni caracterizan a los estados por sus desempeños socioeconómicos e institucionales, Saucedo-Delgado *et al*. (2018: 9) consideran robustos esos resultados a partir de que efectos fijos y otras especificaciones de panel (efectos aleatorios y efectos *pooled*) estiman el efecto de políticas inobservables en el interior de los programas sociales y capturan la heterogeneidad entre individuos, la dinámica temporal y la correlación espacial.

Así, podemos sugerir que el consenso acepta que tanto las estimaciones estáticas de datos panel como los modelos RCT son complementarios, nunca excluyentes y pueden generar resultados consistentes.

Es importante aclarar que RCT requiere muchas observaciones debido a que las secciones transversales de sus datos de panel refieren a beneficiarios (personas) de programas sociales, lo que es distinto a nuestro enfoque en que tratamos a estados del país para estimar el efecto de la política estatal de asignar mayores transferencias monetarias a los pobres, ello nos permite tomar la PEM como variable dependiente en nuestras estimaciones econométricas y vincularla directamente con ese gasto y con un conjunto amplio de variables (económicas, sociales e institucionales) que la explican (lo que no hacen Saucedo-Delgado *et al.,* 2018) y por ello incorporamos los mecanismos adicionales que pueden perpetuarla o erradicarla.

En cuanto a corrupción y pobreza, Jong-Sung y Khagram (2005) aplican MCO2E en una muestra de 129 países y concluyen que la corrupción aumenta a mayor pobreza debido a que los pobres desconocen la actuación de sus gobernantes y carecen de medios para informarse y exigir rendición de cuentas. Aquí radica otro mecanismo de endogeneidad entre el Estado de Derecho y la pobreza.

Para países emergentes y desarrollados, Mauro (1995, 1996, 1998, 2002) prueba con técnicas de variables instrumentales que la corrupción se asocia a la baja calidad de las instituciones, lo que genera múltiples externalidades (como el

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6 Saucedo-Delgado *et al*. (2018: 8) mencionan que a partir de la técnica RCT "el único requisito para la construcción del grupo de tratamiento [beneficiarios] era que el hogar estuviera incluido en el programa *Prospera-Oportunidades*", excluyendo así el efecto de otras variables externas al programa pero que son importantes para erradicar la pobreza.

fracaso de los programas sociales), perpetuando así la pobreza y el estancamiento económico (trampa de pobreza). En particular, Mauro (1995: 706) señala que "las malas instituciones del pasado pueden haber jugado un papel considerable al generar bajo crecimiento económico [debido a la corrupción] que condujo a la pobreza de hoy".

El mecanismo operativo que lo explica es la generación de incentivos perversos en términos de que las autoridades encargadas de administrar y ejercer el presupuesto de los programas sociales reciben mayores recursos cuando la pobreza persiste, por lo que participan con frecuencia en actos de corrupción con el objeto de mantener el problema inicial y sus cargos públicos y así continuar recibiendo ingresos y privilegios (Mauro, 1995). Adicionalmente, sostenemos que las familias en pobreza tienen el incentivo de preservar su condición para así recibir (o continuar recibiendo) las transferencias del gobierno sin hacer ningún esfuerzo adicional ni en reciprocidad.

Negin *et al*. (2010) señalan que la corrupción es consecuencia del atraso en orden, seguridad, justicia y protección de los derechos humanos. Salama y Valier (1995: 60) señalan que "la búsqueda del enriquecimiento personal [objetivo de la corrupción] hace saltar en mil pedazos la cohesión del país, sumergiéndolo en un caos de violencia y pobreza". De acuerdo con Pécaut (1998), la pobreza puede fácilmente romper el tejido social debido a que, al no existir expectativas de mejoramiento de sus condiciones de vida, amplios grupos se involucran en actividades ilícitas diversas, incluyendo el contubernio con las autoridades corruptas que les mejoren sus ingresos. Esto no significa que necesariamente se criminalice la pobreza, pero una razón fundamental del crimen es de carácter estructural como la marginación, la pobreza y las malas expectativas del futuro (De Gante, 2017).

Desde las investigaciones de Mauro (1995, 1996, 1998, 2002) hasta las contribuciones de Banerjee *et al.* (2015) la literatura plantea que corrupción, violencia, impunidad, etc., reflejan en última instancia el Estado de Derecho y al combinarse tienden a configurar externalidades que explican el *efecto cobra*.

El único artículo que encontramos que hace alusión a la hipótesis de incentivos perversos para las regiones de México es el de Ramones y Prudencio (2014) –que utilizan MCO2E– y prueban la hipótesis de que aun el gasto social básico en infraestructura (alumbrado, drenaje y pavimentación) en comunidades marginadas –que es el mínimo para generar condiciones elementales de desarrollo– tiende a incrementar la corrupción y la pobreza moderada multidimensional, y concluyen que el crecimiento de la pobreza conduce a mayor asignación de recursos públicos y mayor corrupción, generando así un círculo vicioso.

Otros trabajos para México –Campos-Vázquez y Monroy-Gómez-Franco (2016) y Hernández-Laos y Benítez-Lino (2014)–, aun cuando no tratan estas endogeneidades y tampoco emplean la medición multidimensional de la pobreza, encuentran diferencias estructurales de la pobreza alimentaria entre estados[7] y

[7] La pobreza alimentaria es medida como el porcentaje de la población que tiene "incapacidad para obtener una canasta básica alimentaria, aun si hiciera uso de todo el ingreso disponible en su hogar", CONEVAL (2020a).

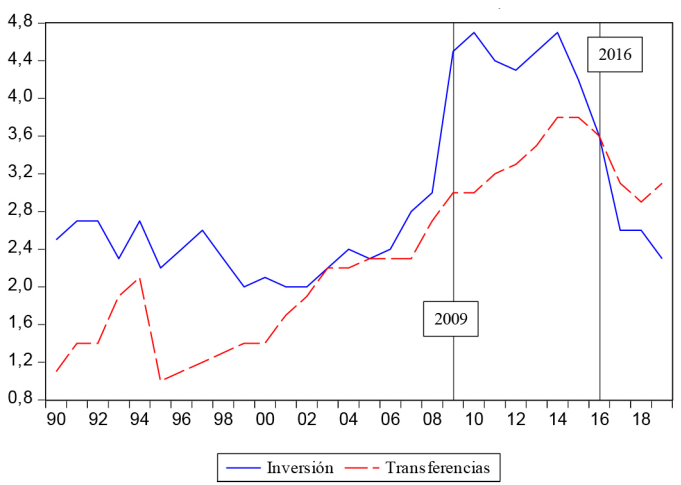
demuestran que el crecimiento económico, la formalidad laboral y los perfiles productivos orientados a la exportación reducen la pobreza en las regiones más ricas y con menor desigualdad, lo que está totalmente en línea con lo que demostramos en este trabajo.

Por último, Loría (2020a) utiliza series anuales de pobreza alimentaria y patrimonial en México (1992-2016) y encuentra que hay tasas de crecimiento del PIB eficientes en reducirla y que el gasto público en pobreza alimentaria no la ha reducido durante 2007-2016. Debido a ello, concluye que, desde la *Gran Recesión* de 2009, México –o quizá algunas de sus entidades– se encuentra en una trampa de pobreza, hipótesis que aquí constatamos utilizando series estatales de pobreza extrema multidimensional.

4. Regularidades empíricas

El Gráfico 1 reporta que desde 2009 el gasto público de inversión se ha venido sacrificando notablemente en favor de las transferencias monetarias directas al grueso de la población (pobres y no pobres) y, desde 2016, este último gasto es mayor al primero.

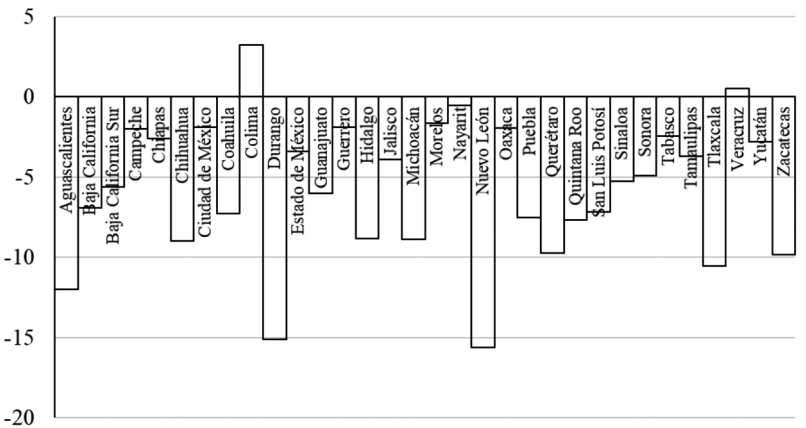
GRÁFICO 1
GASTO PÚBLICO EN % DEL PIB, 1990-2019



Fuente: SHCP (2021).

Sin embargo, y aun a pesar de que ambos rubros del gasto han caído desde 2014, la PEM en los estados se ha reducido con gran heterogeneidad, e identificamos dos casos excepcionales (Colima y Veracruz) en que se ha incrementado[8], ver Gráfico 2.

GRÁFICO 2
ESTADOS DE MÉXICO: CRECIMIENTO MEDIO DE PEM, 2008-2018



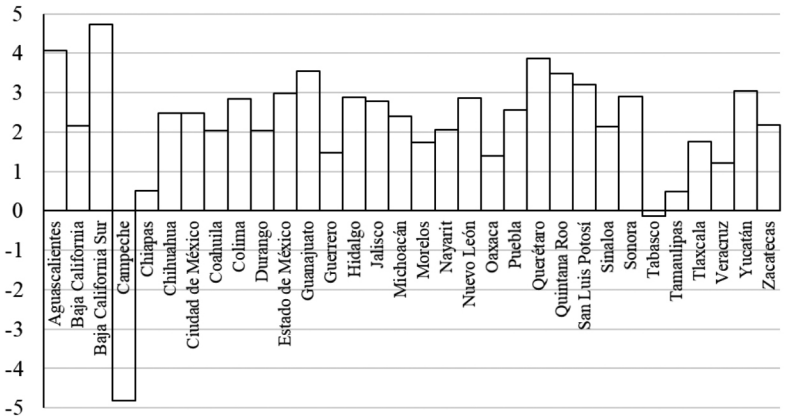
Fuente: elaboración propia con cifras de CONEVAL (2020c).

Por su parte, el crecimiento del PIB (TCY) durante todo el periodo de estudio también reporta dinámicas muy heterogéneas (ver Gráfico 3) y destacan particularmente las únicas caídas de Campeche y Tabasco, que son estados muy atípicos por su baja población, alta pobreza y que sus variables económicas tradicionalmente se han vinculado a la actividad y a la renta petrolera, por lo que la caída de las exportaciones y los choques negativos en el precio internacional del petróleo desde 2014 explican que hayan sido los únicos estados con decrecimiento económico. Además, sus altos niveles de PIB *per cápita* y de productividad

8 Como hipótesis, y en congruencia con nuestro enfoque teórico, sugerimos que este resultado puede estar asociado a la alta y creciente tasa de homicidios dolosos en Colima y Veracruz, quienes en 2018 reportaron 81 y 17 casos por cada 100 mil habitantes, respectivamente (SESNSP, 2020), que refleja graves problemas de violencia incontrolable que rompe los vínculos familiares, debilita la cohesión social (Salama 2013: 12) y se vuelve fuente de anomia (Durkheim, 1893); en el sentido que la falta de orden, seguridad y justicia ha debilitado la estructura social que provee a los individuos de lo necesario para lograr sus metas vitales más elementales.

laboral muestran considerables sesgos al alza, que contrastan con las demás variables, por lo que los omitimos en nuestras estimaciones econométricas[9].

GRÁFICO 3
ESTADOS DE MÉXICO: CRECIMIENTO MEDIO DEL PIB REAL, 2008-2018



Fuente: elaboración propia con cifras de INEGI (2020).

Con la finalidad de capturar adecuadamente la gran heterogeneidad de los desempeños socioeconómicos e institucionales de los estados del país con criterios teóricos y estadísticos robustos, seguimos la agrupación (no regionalización) de Loría *et al*. (2020), que no responde a criterios geográficos, sino a la hipótesis de heterogeneidad estructural que considera un conjunto muy amplio y diverso de indicadores.

A pesar de que varias instituciones mexicanas tienen regionalizaciones *ad hoc*, no es pertinente utilizarlas aquí debido a que son agrupaciones con estados que no necesariamente comparten características semejantes de desarrollo socioeconómico y de Estado de Derecho como lo hacemos nosotros. Por ejemplo, el INEGI (1978) utiliza un Índice Demográfico que mide el nivel de urbanización y ubica 5 regiones. El Banco de México (2020), por su parte, considera 4

[9] Este procedimiento de exclusión es común en el análisis aplicado, así como lo hacen Saucedo-Delgado *et al*. (2018) para Campeche y Chiapas y se aplica convencionalmente para estimar y explicar congruentemente a un conjunto amplio de individuos, eliminando así los problemas de sesgo y significancia estadística que generan observaciones atípicas (*outliers*). Sin embargo, hay que decir que esos individuos atípicos se pueden incorporar en las estimaciones mediante variables *dummies* si interesa identificar y analizar expresamente esos individuos atípicos a partir de hipótesis específicas, pero no es el caso de nuestro trabajo, que busca generalidades satisfactorias en torno a nuestra hipótesis central.

regiones a partir de que los estados comparten vecindad geográfica y coincidencia de sus ciclos económicos. Finalmente, CONEVAL (2014: 80) utiliza criterios demográficos (crecimiento poblacional), grado de urbanización y desempeños del PIB *per cápita* y de crecimiento económico (variables sesgadas en algunos estados como vimos en el Gráfico 3) para dividir al país en 5 regiones.

Otro factor que nos llevó a evadir las regionalizaciones de estas instituciones es que al adoptar cualquiera de ellas reduciríamos dramáticamente los grados de libertad, complicando seriamente la inferencia estadística que hacemos en las estimaciones de panel y, sobre todo, en las de sección cruzada.

En la introducción mencionamos que la agrupación de Loría *et al*. (2020) divide al país en dos. El primer grupo está compuesto por 22 estados que, aunque presentan heterogeneidad, claramente muestran mejor desempeño en todas las variables de desarrollo socioeconómico e institucional (que determinan G1) y un segundo grupo (G2) integrado por 8 estados homogéneos en cuanto a que presentan muy bajo desarrollo.

En la Tabla 1 observamos que este criterio de agrupación (G1 y G2) responde claramente a la hipótesis de heterogeneidad estructural y observamos las siguientes regularidades que son cruciales:

1. Las transferencias monetarias a los pobres son sustancialmente mayores en G2 respecto de G1 (70% mayores) y la pobreza extrema multidimensional es casi el triple.
2. La elevada pobreza en G2 refleja sus grandes rezagos de productividad laboral (YL_i), su mayor ocupación en el sector primario y menor en el secundario y terciario.
3. La producción de G2 se vincula en mayor medida con el sector primario, con el empleo precario e informal y con el mercado interno (por su bajo coeficiente de exportaciones). Esto refleja perfiles más intensivos en trabajo que en capital, con poco valor agregado y bajos salarios.
4. La elevada proporción de empleos precarios en G2 podría asociarse a la baja calidad de vida (salud física y emocional) de sus trabajadores y de sus familias (Arias-Uriona y Ordóñez, 2018) y, por tanto, a su baja productividad y remuneraciones.
5. La menor calidad relativa de las instituciones en G2 (Índice de Estado de Derecho más bajo) podría asociarse a corrupción y violencia (Mauro, 1995). Conviene decir que aunque la diferencia es marginal respecto de G1, es muy significativa para las estimaciones que se presentan más adelante y congruente con nuestro enfoque.
6. La mayor tasa de criminalidad en G2 (en todas sus modalidades) es razón y causa de su baja condición de desarrollo. En concreto, afecta la generación de valor y la calidad y cantidad de empleos debido a que dificultan la actividad empresarial, sobre todo de los negocios pequeños y micro y también inhiben la inversión extranjera. En este sentido, Becker (1968) y Rizzo (1979) señalan que altos niveles de criminalidad debilitan la cohesión social y deprimen la inversión privada, lo que reduce la actividad económica y aumenta la pobreza.

TABLA 1
MÉXICO: HETEROGENEIDAD ESTRUCTURAL, 2008-2018

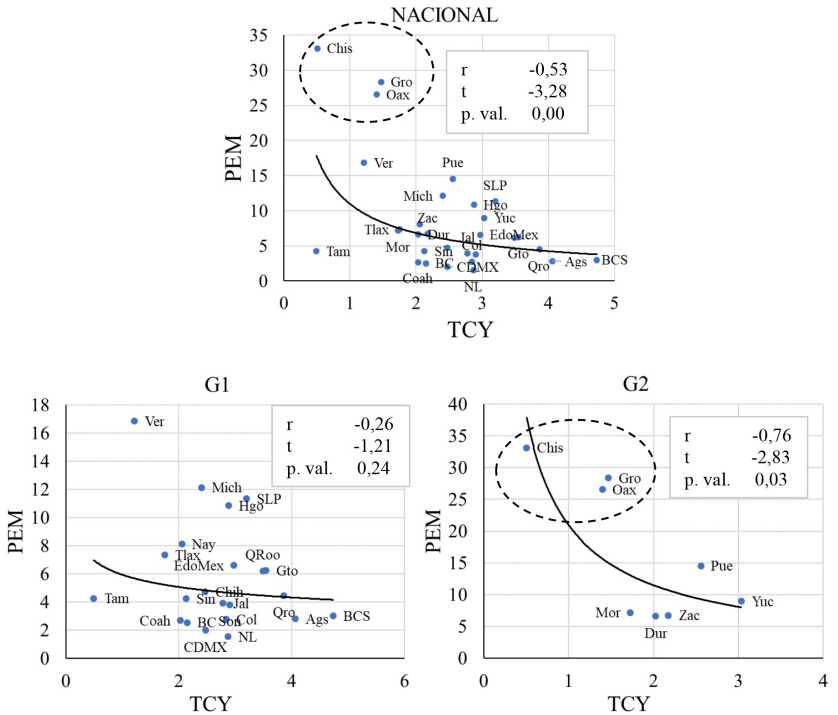
Variable	Nacional				G1				G2			
	μ	σ total	σ inter	σ intra	μ	σ total	σ inter	σ intra	μ	σ total	σ inter	σ intra
PEM[1]	8,7	8,18	7,98	2,22	5,8	4,22	3,91	1,76	16,5	10,94	11,07	3,18
TCY[2]	2,1	1,6			2,6	0,9			1,9	0,8		
YPC	0,13	0,05	0,05	0,01	0,14	0,05	0,05	0,01	0,08	0,02	0,21	0,00
YLP	0,12	0,07	0,07	0,18	0,13	0,07	0,07	0,02	0,07	0,05	0,05	0,01
YLS	0,37	0,15	0,14	0,04	0,40	0,15	0,15	0,04	0,29	0,09	0,09	0,04
YLT	0,31	0,10	0,10	0,02	0,33	0,11	0,11	0,02	0,24	0,02	0,02	0,01
TMGP	65,5	63,8	33,82	54,20	55,3	41,8	20,48	36,66	93,7	97,54	46,10	87,27
Exportaciones[3]	28,0	32,1	31,15	9,33	32,7	35,70	34,77	10,57	14,8	11,52	11,23	4,47
Ingreso laboral per cápita[4]	1,8	0,52	0,51	0,13	1,9	0,46	0,45	0,15	1,3	0,27	0,28	0,07
PIB sectorial (%):												
Primario	5	2,87	2,88	0,38	4	2,96	2,99	0,40	6	2,22	2,33	0,31
Secundario	31	9,32	9,27	1,82	32	10,18	10,23	1,74	29	5,95	5,91	2,03
Terciario	64	9,34	9,33	1,80	64	10,20	10,25	1,74	65	6,61	6,68	1,97
Empleo sectorial (%):												
Primario	15	9,53	9,60	1,12	11	6,90	6,96	1,00	24	9,78	10,23	1,41
Secundario	25	6,55	6,45	1,60	26	6,79	6,71	1,69	21	4,51	4,55	1,35
Terciario	60	8,18	8,18	1,40	63	7,65	7,65	1,48	55	6,52	6,79	1,16
TCCO	11,9	6,08	5,87	1,87	10,0	4,39	4,08	1,80	17,3	6,89	6,96	2,05
TIL	57,6	12,86	12,90	1,87	53,1	11,03	11,05	2,06	69,9	8,85	9,27	1,23
Tasas de criminalidad:[5]												
Homicidios	18,8	17,35	13,50	11,12	18,2	17,28	13,13	11,52	20,1	17,63	15,32	10,05
Secuestros	1,0	1,19	0,81	0,89	0,9	1,08	0,73	0,81	1,2	1,44	0,10	1,08
Extorsiones	5,0	5,01	3,59	3,55	4,9	4,57	3,51	3,00	5,1	6,12	4,05	4,77
IED[6]	0,39	0,03			0,39	0,02			0,38	0,05		

Fuente: Elaboración propia.
Nota: μ es el promedio aritmético y σ es la desviación estándar que se descompone en 3: $\sigma \text{ total} = \sqrt{\frac{\sum (x_{it} - \bar{x})^2}{NT-1}}$; ; $\sigma \text{ inter} = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{N-1}}$ y $\sigma \text{ intra} = \sqrt{\frac{\sum (x_{it} - \bar{x}_i)^2}{NT-1}}$. Las variables de producción, de productividad sectorial y TMGP se expresan en millones de pesos constantes del 2013. [1] % de la población total; [2] Crecimiento medio del PIB; [3] % del PIB; [4] Miles de pesos constantes del 2010; [5] Eventos por cada 100 mil habitantes; [6] Valores cercanos a 1 indican más adhesión al Estado de Derecho. Consultar fuentes y definiciones en tabla 1A.

7. Por último, y para reforzar de modo contundente nuestro enfoque basado en la hipótesis de heterogeneidad estructural, calculamos la desviación estándar total (σ) que considera conjuntamente la variación entre individuos y en el tiempo respecto de la media total, que se puede descomponer en σ *inter* que expresa la variación (desviación estándar) entre estados y, por último, σ *intra* que refiere a la desviación estándar en el tiempo (Greene 2012: 357). Si bien estos estadísticos en PEM y en TMGP son notablemente mayores en G2, los estadísticos σ_i de todos los tipos de productividad laboral y de exportaciones son mucho más bajos respecto de G1. Esto evidencia que al incorporar estas variables en los modelos econométricos de panel obtenemos resultados que apuntan en favor de que G2 tiene rezagos profundos y homogéneos entre los 8 estados que lo constituyen.

El Gráfico 4 aproxima la influencia del crecimiento económico para la creación/solución de la trampa de pobreza en términos de la relación no lineal, negativa y significativa entre TCY y PEM (promedio aritmético) a nivel nacional y para G2. Destaca que para G1, si bien la relación también es negativa, no es

GRÁFICO 4
TCY Y PEM, 2008-2018

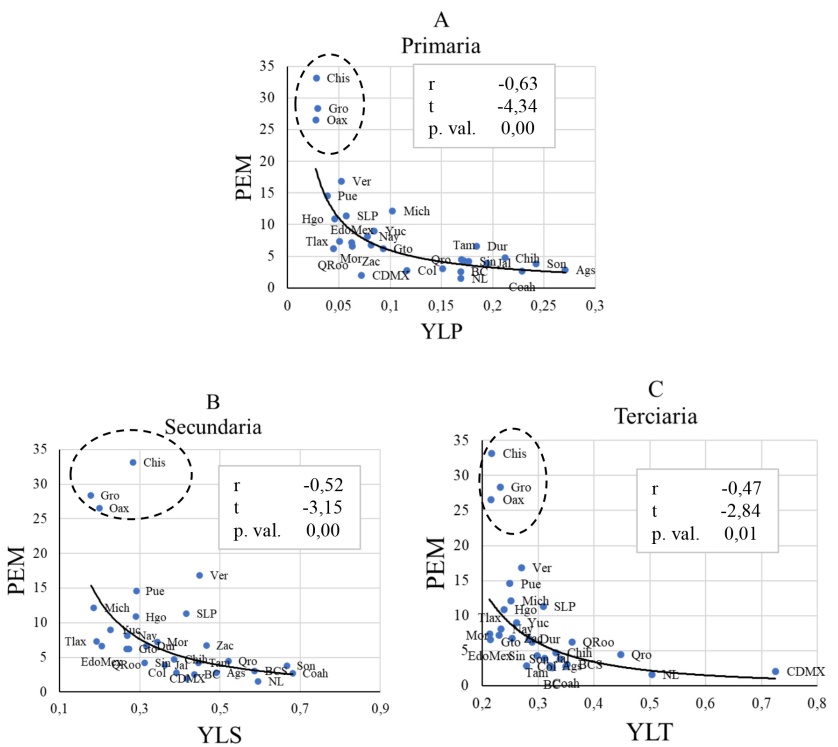


Fuente: Elaboración y cálculos propios con datos de INEGI (2020) y CONEVAL (2020c).

estadísticamente significativa, quizás por la gran dispersión de los datos (estados heterogéneos) y porque son los estados que mejor desempeño tienen. Para el total nacional y G2 apreciamos un ajuste muy marcado[10], cuya curvatura refleja que para erradicar PEM no solo importa el crecimiento económico (Medina y Galván, 2014: 7), sino también la mejoría del conjunto de variables en la Tabla 1, sobre todo en los estados agrícolas (rurales) más rezagados que conforman G2. En ese gráfico y para las siguientes destaca siempre la relevancia de Chiapas (Chis), Guerrero (Gro) y Oaxaca (Oax) que se caracterizan por ser los estados más pobres del país.

De acuerdo con CEPAL (2016: 28), una variable crucial que vincula la relación anterior es la productividad media laboral primaria (YLP), que se muestra en el Gráfico 5A. De acuerdo con el valor de la correlación parcial,

GRÁFICO 5
PEM Y PRODUCTIVIDAD LABORAL MEDIA SECTORIAL (YLI), 2008-2018



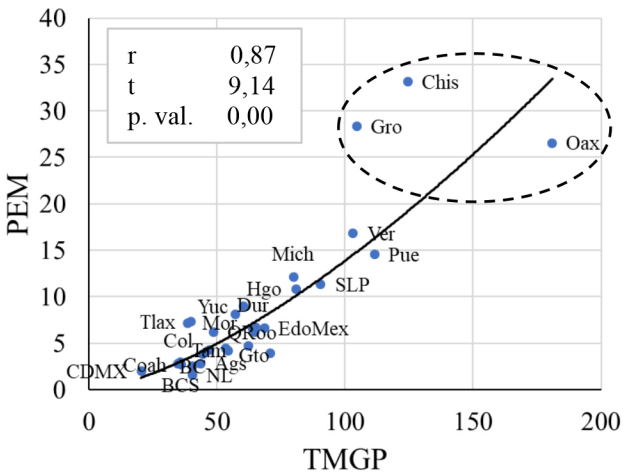
Fuente: Elaboración propia con cifras de INEGI (2020).

10 El ajuste resulta de la siguiente ecuación exponencial: $y = ce^{bx}$; donde c y b son constantes y e es la base del logaritmo.

observamos que YLP es la productividad sectorial más asociada con PEM, lo que comprueba la hipótesis de Deaton (2013) y de Banerjee *et al*. (2015) en cuanto a que los esfuerzos del gobierno por reducir la pobreza deben centrarse en elevar la productividad del sector primario.

Por último, el Gráfico 6 es crucial para el propósito de todo nuestro trabajo en virtud de que muestra la alta correlación positiva (la mayor de todas las relaciones) entre TMGP y PEM, además de que probamos que existe clara precedencia estadística (causalidad en el sentido de Granger con datos panel, *Stacked Test*) de uno a cuatro rezagos[11]. Al igual que en los gráficos anteriores, ahora en el extremo superior derecho aparecen los mismos estados que reportan los peores resultados de crecimiento, desarrollo y pobreza.

GRÁFICO 6
MÉXICO: PEM Y TMGP, 2008-2018



Fuente: Elaboración propia con cifras de CONEVAL (2020c) y SHCP (2020).

[11] Prueba con 4 rezagos. Ho: TMGP no causa PEM, F(60, 2,84), p. value = 0,03. Ho: PEM no causa TMGP: F(60, 0,043), p. value = 0,78.

5. Aspectos econométricos

Para probar empíricamente nuestra hipótesis seguimos la siguiente estrategia econométrica. Primero estimamos modelos con datos de panel para atender la hipótesis de heterogeneidad estructural, que hacemos para G1, G2 y las 30 entidades (total nacional); después, con datos de sección cruzada con GMM estimamos la importancia del Índice de Estado de Derecho para explicar PEM solo para G1 y G2.

5.1. Regresiones de panel

Utilizamos un panel balanceado en virtud de que todos los estados (i) tienen el mismo periodo (observaciones), a la vez que cumple las características de un micropanel –también llamado panel corto– ya que $i > t$ (30 *vs* 6).

Enfatizamos que nuestras secciones transversales refieren a estados, no a beneficiarios de programas sociales, lo que no requiere la adición de variables respecto de la estructura poblacional de PEM (edad, sexo, etnia, etc.) que podrían influir en el comportamiento de esos segmentos; sin embargo, demostrarlo se sale del propósito de esta investigación.

Especificamos a TMGP (transferencias), Y (PIB real) e YLP (productividad laboral primaria) en logaritmos como los regresores explicativos (variables de control) de PEM (pobreza extrema multidimensional) con constante y siempre obtuvimos resultados congruentes con nuestras hipótesis:

$$(1) \qquad \log(PEM_{i,t}) = c_{i,t} + \beta_1 * \log(TMGP_{i,t}) + \beta_2 * \log(Y_{i,t}) + \beta_3 * \log(YLP_{i,t}) + \varepsilon_{i,t}$$

En concordancia con la probable existencia de endogeneidad entre estas variables (Anser *et al*., 2020), que es muy común en este tema, planteamos que el crecimiento económico disminuye PEM y la endogeneidad se da en términos de que PEM puede restringirlo por la hipótesis de trampa de pobreza. Además, PEM puede asociarse a menor YLP y también existe la posibilidad de que TMGP esconda endogeneidades con PEM por la asignación del presupuesto a las entidades más marginadas (Ramones y Prudencio, 2014). Otro mecanismo de endogeneidad ocurre cuando la pobreza puede deteriorar el Estado de Derecho en muchos sentidos (corrupción, violencia, criminalidad, impunidad, etc.) y viceversa.

Adicional a las variables de control, agregamos 3 regresores: a) el coeficiente de exportaciones a producto (XPIB), b) la tasa de informalidad laboral (TIL) y c) la tasa de homicidios dolosos (TH); todas ellas también en logaritmos y se presentan en minúsculas. De acuerdo con CEPAL (2016: 28), estas variables reflejan las diferencias (brechas) estructurales entre los mercados locales (estatales) y, por tanto, también son determinantes de PEM.

Estimamos 4 modelos por cada grupo (Tabla 3). El primer modelo solo incorpora los tres regresores de control (transferencias, PIB y productividad) de la ecuación (1). El segundo modelo agrega el coeficiente de exportaciones a

producto como regresor adicional. El tercer modelo sustituye esta variable por la tasa de informalidad laboral. El cuarto sustituye la informalidad por la tasa de homicidios dolosos. Aquí radica la distinción entre las 4 especificaciones para el Nacional, G1 y G2, dando en total 12 modelos (estimaciones distintas). Hay que advertir que al incorporar conjuntamente todos los regresores en cualquiera de los grupos no obtenemos resultados significativos.

De acuerdo con Baltagi (2005: 237), los micropaneles (cortos) relajan la condición de estacionariedad en las variables, al grado de que frecuentemente no es una preocupación y tienden a no reportarse las pruebas de raíz unitaria. Sin embargo, mostramos la prueba de *raíz unitaria común* de Levin *et al*. (2002), ver Tabla 2A en el Anexo, que se basa en la suposición de que el proceso AR(1) posee un coeficiente asociado a la variable rezagada que es común (invariante) entre individuos.

De acuerdo con la prueba para paneles balanceados de *raíz unitaria común* (Levin *et al*., 2002), todas las variables son estacionarias, por lo que las estimaciones y los resultados están libres de espuriedad.

Una gran ventaja de estimar con datos de panel en relación con otras estructuras de datos es que brindan más información del fenómeno económico, ofrecen más grados de libertad, existe menor probabilidad de encontrar colinealidad y atienden la dinámica temporal y la heterogeneidad de los individuos (Klevmarken, 1989; Hsiao, 2014).

Adicionalmente –y a diferencia de RCT (Banerjee *et al*., 2015 y Saucedo-Delgado *et al*., 2018)– la ecuación (1) permite estimar el efecto de variables importantes en general omitidas o no observables en el interior de los programas sociales, que podrían estar influyendo en la pobreza (Greene, 2012: 345), así como el cambio entre distintas unidades transversales, con lo que es posible identificar otras políticas y variables que pueden explicar quizá con mayor eficiencia a PEM.

En concordancia con una práctica econométrica adecuada, en la Tabla 2 mostramos las pruebas de correcta especificación de los modelos para G1, G2 y del nacional.

Para el total nacional y G1 sobresalen los siguientes resultados de las pruebas de correcta especificación:

1. El rechazo de la prueba de Hausman (1978) indica que existe correlación entre los errores (individuales y temporales) con los regresores; es decir, que no se cumple con exogeneidad estricta entre estados ni en el tiempo. Se prueba así que los efectos aleatorios (EA) no son significativos y la alternativa es estimar por el método más consistente de efectos fijos (EF). También es indicativo de que *pem* depende de otras variables.
2. Rechazamos la prueba de EF redundantes en sección cruzada, que es indicativo de heterogeneidad en términos de que la constante varía significativamente entre individuos. Además, rechazamos la prueba de EF redundantes en periodos, lo que prueba que existen efectos temporales; es decir, la constante también varía significativamente en el periodo de estudio (2008-2018).

TABLA 2
PRUEBAS DE PANEL, 2008-2018

Grupo	Variables	Prueba								
		Hausman χ^2		Efectos Fijos redundantes χ^2		Breusch-Pagan LM	Pesaran CD	Jarque-Bera	Wooldridge	Wald
		Ho								
		EA en sección cruzada	EA en periodo	Secciones cruzadas redundantes	Periodo redundante	Variación panel = 0	Errores i.i.d.	Normalidad	No autocorrelación serial de orden 1	Errores homoscedásticos
Nacional	-	75,25 (0,00)	22,49 (0,00)	259,07 (0,00)	24,74 (0,00)		4,64 (0,00)	12,33 (0,00)	9,65 (0,00)	1209,24 (0,00)
	xpib	74,04 (0,00)	14,23 (0,01)	253,10 (0,00)	21,77 (0,00)		4,66 (0,00)	13,36 (0,00)	10,79 (0,00)	978,95 (0,00)
	til	50,29 (0,00)	11,23 (0,02)	215,56 (0,00)	18,47 (0,00)		4,07 (0,00)	6,79 (0,03)	7,27 (0,01)	899,58 (0,00)
	th	76,17 (0,00)	20,36 (0,04)	259,16 (0,00)	24,20 (0,00)		4,88 (0,00)	7,94 (0,02)	9,65 (0,00)	2483,27 (0,00)
G1	-	59,63 (0,00)	19,95 (0,00)	185,37 (0,00)	23,07 (0,00)		3,15 (0,00)	10,41 (0,00)	6,56 (0,02)	1425,05 (0,00)
	xpib	57,05 (0,00)	6,15 (0,19)	179,23 (0,00)	20,57 (0,00)		3,14 (0,00)	10,60 (0,00)	7,10 (0,01)	1390,28 (0,00)
	til	43,15 (0,00)	11,57 (0,02)	156,65 (0,00)	17,77 (0,00)		1,67 (0,09)	4,68 (0,10)	5,11 (0,03)	487,08 (0,00)
	th	60,29 (0,00)	16,92 (0,00)	186,37 (0,00)	22,70 (0,00)		3,47 (0,00)	6,87 (0,03)	6,39 (0,02)	3677,40 (0,00)

Continuación Tabla 2

Grupo	Variables	Prueba								
		Hausman χ^2		Efectos Fijos redundantes χ^2		Breusch-Pagan LM	Pesaran CD	Jarque-Bera	Wooldridge	Wald
		Ho								
		EA en sección cruzada	EA en periodo	Secciones cruzadas redundantes	Periodo redundante	Variación panel = 0	Errores i.i.d.	Normalidad	No autocorrelación serial de orden 1	Errores homoscedásticos
G2	-	6,60 (0,09)	2,16 (0,54)			23,70 (0,00)	0,54 (0,59)	0,20 (0,91)	3,42 (0,11)	
	xpib	8,19 (0,08)	9,03 (0,06)			0,53 (0,47)	1,35 (0,18)	0,95 (0,62)	4,03 (0,08)	
	til	8,86 (0,06)	2,49 (0,65)			24,30 (0,00)	1,05 (0,29)	0,94 (0,62)	3,06 (0,12)	
	th	3,65 (0,45)	3,03 (0,55)			23,59 (0,00)	0,67 (0,50)	0,03 (0,98)	3,17 (0,12)	

Fuente: Elaboración propia.
–indica que solo se estimó con los regresores de control (tmgp, y, ylp). La prueba de Wald solo aplica en modelos estimados por efectos fijos.
Entre paréntesis son probabilidades.

3. La variación de la constante en ambos sentidos (entre individuos y en el tiempo) en todos los modelos del grupo Nacional y G1 es evidencia de *Two Way Fixed Effects*. La prueba de Hausman (1978) y de EF redundantes en periodos sugieren este resultado; sin embargo, se efectúan con muy pocos grados de libertad (a lo mucho 5) y se dificulta enormemente la inferencia estadística. Por tanto, decidimos controlar por EF solo los errores individuales en virtud de que cuenta con más grados de libertad (30 estados) y dejamos sin tratamiento el subíndice *t* (tiempo) de las variables.
4. El rechazo de Ho de la prueba de Pesaran (2004) y de Jarque-Bera (1980) nos advierte de la existencia de dependencia en sección cruzada y de no normalidad. El único modelo que pasa ambas pruebas es G1 con las tres variables de control más *til*.
5. La prueba de Wald (Greene, 2003) muestra que existe heterocedasticidad de los residuos en favor la heterogeneidad de esos estados.
6. La prueba de correlación serial de Wooldridge (Drukker, 2003) muestra que existe autocorrelación serial de orden 1, por lo que las desviaciones estándar de los coeficientes de la estimación se reportan más bajos de lo que en realidad son, además de que la R^2 se reporta más alta de lo que en realidad es. Esta prueba nos advierte que *pem* actual depende del desempeño pasado de los regresores, como actividad económica, transferencias monetarias a los pobres, productividad laboral primaria, exportaciones a PIB, tasa de informalidad laboral y homicidios dolosos.

En cuanto a G2, las pruebas de correcta especificación indican lo siguiente:

1. En el modelo con *xpib* no rechazamos las pruebas de Hausman (1978) ni de Breusch-Pagan (1979) al mismo tiempo, lo que indica que es el único grupo en que es preferible usar efectos agrupados o *pooled* (EP); es decir, PEM en esos estados tiende hacia una media común que es elevada y fija en el tiempo (Wooldridge 2002: 170). Asimismo, estas pruebas en los modelos con *til*, *th* y solo con las variables de control indican que es preferible EA como el método más eficiente porque existe exogeneidad estricta y efecto panel.
2. Los residuos en todos los modelos presentan normalidad y no existe dependencia en sección cruzada, lo que significa que no existe efecto espacial y prueba su gran homogeneidad.

En síntesis, y con base en las pruebas anteriores, concluimos que EF es eficiente para el nacional y G1, y EA y EP para G2.

Blindamos las 12 estimaciones de panel contra autocorrelación serial y heterocedasticidad con la matriz White period (*cross-section cluster*) que genera errores estándar y covarianzas robustas de los parámetros (Arellano, 1987; Wooldridge, 2002: 148-153), con lo que obtenemos estimaciones robustas (eficientes).

La Tabla 3 muestra los resultados de las estimaciones para el total nacional, G1 y G2 y sobresale lo siguiente:

1. La bondad de ajuste (R^2) en el nacional y G1 es muy alta, mucho mayor que en G2.
2. En G2 sus constantes difieren marginalmente y el método EP del modelo (10) generó la R^2 más elevada del grupo, lo que apunta en favor de nuestra hipótesis de gran homogeneidad.
3. Validamos la hipótesis del *efecto cobra* en G2 con base en el coeficiente asociado a *tmgp* en los modelos (9) a (12), que siempre tienen signos positivos y significativos. Lo contrario ocurre en G1 en que los signos de *tmgp* siempre son negativos, pero no significativos, modelos (5) a (8).
4. Los coeficientes asociados a *y* en todos los modelos −salvo en el modelo (10)− son correctos (negativos) y estadísticamente significativos, y destaca que son muy elásticos en el nacional y en G1, lo que da cuenta de que el incremento del producto reduce PEM de manera más que proporcional y en G2 son inelásticos.
5. El signo de *ylp* siempre es negativo y significativo en todos los modelos y *pem* se reduce más que proporcionalmente y de manera única en G2, modelos (9) y (12).
6. *xpib* tiene signo negativo, pero solo es significativo en G2, modelo (10).
7. *til* es positiva y es la mayor en el modelo (11) de G2 al 90% de confianza.
8. El signo positivo y estadísticamente significativo de *th* en los modelos (4) y (8) da cuenta de que la violencia (descomposición social) es un factor importante que incrementa *pem* en G1 y a nivel nacional. Llama la atención que no es significativa en G2 a pesar de que todas las tasas de incidencia delictiva en ese grupo son mayores.

Para atender el problema de endogeneidades que ya referimos, que es muy común en este tema, muchos autores (Ramones y Prudencio, 2014; Imai *et at.* 2014; Donou-Adonsou y Sylwester, 2016) sugieren usar técnicas econométricas de variables instrumentales con MCO2E, que consiste en la adición de $Z_{i,t}$ instrumentos que explican teórica y estadísticamente a los regresores, pero al mismo tiempo cumplen la siguiente condición de ortogonalidad (no estar relacionados con los residuos), (Greene 2012: 223):

$$E\left[(pem_{i,t} - c - \beta X^{'}), Z_{i,t}\right] = 0 \tag{2}$$

Donde *X'* son los regresores.

Es admisible aclarar que el número de instrumentos necesariamente debe ser mayor al número de parámetros en aras de cumplir la condición de sobreidentificación, permitiendo así aplicar las pruebas de validez de los instrumentos. Las pruebas basadas en el valor de la función objetivo (estadísticos J y F, Stock y Watson, 2012: 303) muestran contundentemente que los instrumentos no son débiles, como lo hacen Imai *et al*. (2014).

Los primeros dos instrumentos que usamos son el número de empleados de los sectores secundario y terciario que son de baja especialización técnica,

TABLA 3
ESTIMACIÓN PANEL MCO: RESULTADOS, 2008-2018

	Grupo											
	Nacional					G1				G2		
	Modelo											
	1	2	3	4	5	6	7	8	9	10	11	12
	Método											
	EF					EF			EA	EP	EA	EA
c	28,56	28,44	17,94	30,10	30,20	29,38	20,36	32,78	4,13	-2,05	-2,62	4,99
ee.	[2,42]	[2,77]	[4,40]	[2,41]	[2,73]	[3,12]	[7,31]	[2,89]	[3,28]	[1,47]	[5,12]	[2,73]
t	(11,78)	(10,27)	(4,08)	(12,48)	(11,08)	(9,43)	(2,79)	(11,33)	(1,26)	(-1,39)	(-0,51)	(1,83)
tmgp	0,01	0,00	0,03	0,00	-0,01	-0,01	-0,01	-0,02	0,17	0,18	0,17	0,16
ee	[0,02]	[0,02]	[0,03]	[0,02]	[0,03]	[0,04]	[0,04]	[0,03]	[0,06]	[0,05]	[0,06]	[0,03]
t	(0,40)	(0,14)	(0,95)	(0,19)	(-0,43)	(-0,30)	(-0,28)	(-0,58)	(2.78)	(3,93)	(2,89)	(4,71)
y	-2,16	-2,14	-1,77	-2,28	-2,27	-2,20	-1,94	-2,48	-0,44	0,22	-0,46	-0,53
ee	[0,18]	[0,21]	[0,24]	[0,18]	[0,20]	[0,23]	[0,36]	[0,22]	[0,25]	[0,13]	[0,23]	[0,28]
t	(-12,09)	(-10,24)	(-7,52)	(-12,77)	(-11,20)	(-9,51)	(-5,36)	(-11,43)	(-1.80)	(1,69)	(-1,98)	(-1,91)
ylp	-0,29	-0,28	-0,18	-0,25	-0,28	-0,27	-0,16	-0,23	-1,10	-0,68	-0,75	-1,13
ee	[0,09]	[0,10]	[0,10]	[0,11]	[0,08]	[0,14]	[0,06]	[0,09]	[0,18]	[0,08]	[0,31]	[0,41]
t	(-3,03)	(-2,87)	(-1,80)	(-2,29)	(-3,65)	(-1,94)	(-2,56)	(-2,62)	(-6,21)	(-8,52)	(-2,39)	(-2,77)
xpib		-0,02				-0,03				-0,36		
ee		[0,04]				[0,05]				[0,05]		
t		(-0,64)				(-0,72)				(-6,52)		
til			1,46				1,48				1,88	
ee			[0,47]				[0,67]				[1,06]	
t			(3,08)				(2,20)				(1,78)	
th				0,06				0,08				0,05
ee				[0,03]				[0,03]				[0,05]
t				(2,13)				(2,59)				(0,90)
R^2	0,97	0,97	0,97	0,97	0,96	0,96	0,96	0,96	0,56	0,89	0,57	0,55

Fuente: Elaboración propia. Redondeamos los resultados a dos decimales.
ee = error estándar.
t = t estadístico.

condicionando así su baja productividad, bajos salarios y su alta pobreza. El tercer instrumento es la productividad media del trabajo en el sector terciario, que en México ha sido en servicios no exportables de bajo valor agregado. El cuarto y quinto instrumento son el ingreso laboral *per cápita* y el PIB *per cápita*, que reflejan los resultados en desarrollo y puede asociarse al crecimiento económico (Azariadis y Stachurski, 2005). Por último, agregamos la tasa de condiciones críticas de ocupación en virtud de que puede estar determinando la baja productividad de los trabajadores e incentivos perversos (delincuencia y *efecto cobra*).

Como resultado de agregar estos instrumentos, disminuyen los errores estándar y, por tanto, elevamos la eficiencia de las t-estadísticas. Ver Tabla 4.

De acuerdo con Stock y Watson (2012: 303), el estadístico F mayor a 10 demuestra que nuestros instrumentos son sólidos, explican a los regresores endógenos y es indicativo de que los estimadores convergen asintóticamente a su valor poblacional, y el estadístico J no permite rechazar la hipótesis nula de que los instrumentos en conjunto son válidos. Es muy importante señalar que MCO2E corrigió el problema de dependencia en sección cruzada (correlación contemporánea) de los modelos anteriores, con ello se obtuvieron resultados eficientes y que permiten hacer inferencia estadística contundente.

El ajuste (R^2) con MCO2E tiene cambios marginales respecto de MCO y algunos coeficientes tienen cambios como lo sugieren otros autores que aplican esta técnica (Imai *et al*., 2014), pero sin afectar nunca el sentido económico de nuestra hipótesis; de hecho, se refuerza. En específico, ahora las transferencias se vuelven significativas a nivel nacional y en G1 (modelos 1, 3, 5 y 6) en el sentido de que reducen significativamente la pobreza, y se mantienen en G2 en cuanto a que la perpetúan. El efecto pernicioso de la violencia y la informalidad ahora es significativo en G2 y mayor que en G1. Por último, la actividad productiva (exportaciones y PIB real) se vuelve significativa a nivel nacional y en G1, por lo que se corrobora que es un instrumento importante de combate a la pobreza, que ha tenido mejores resultados que en G2.

TABLA 4
ESTIMACIÓN PANEL MCO2E: RESULTADOS, 2008-2018

	Grupo											
	Nacional				G1				G2			
	Modelo											
	1	2	3	4	5	6	7	8	9	10	11	12
	Método											
	EF				EF				EA	EP	EA	EA
c	32,39	17,80	2,16	24,04	33,71	24,98	18,59	30,85	3,22	-0,99	-15,16	4,31
ee.	[4,14]	[8,35]	[5,35]	[4,08]	[6,66]	[7,04]	[6,64]	[5,41]	[1,62]	[0,52]	[6,55]	[2,68]
t	(7,83)	(2,13)	(0,40)	(5,89)	(5,06)	(3,55)	(2,80)	(5,70)	(1,99)	(-1,87)	(-2,31)	(1,61)
tmgp	-0,17	-0,04	0,14	-0,03	-0,19	-0,15	-0,05	-0,11	0,14	0,27	0,19	0,21
ee	[0,05]	[0,11]	[0,02]	[0,05]	[0,10]	[0,07]	[0,12]	[0,09]	[0,03]	[0,11]	[0,07]	[0,06]
t	(-3,15)	(-0,34)	(5,99)	(-0,48)	(-1,93)	(-2,17)	(-0,44)	(-1,22)	(4,85)	(2,56)	(2,48)	(3,74)
y	-2,66	-1,28	-0,89	-2,03	-2,69	-1,76	-1,85	-2,52	-0,38	0,03	-0,58	-0,52
ee	[0,31]	[0,58]	[0,26]	[0,29]	[0,48]	[0,52]	[0,43]	[0,37]	[0,16]	[0,07]	[0,28]	[0,24]
t	(-8,49)	(-2,22)	(-3,33)	(-6,95)	(-5,64)	(-3,40)	(-4,09)	(-6,80)	(-2,39)	(0,36)	(-2,04)	(-2,15)
ylp	-1,63	-0,89	-0,47	-1,48	-1,41	-0,64	-0,68	-1,47	-1,17	-0,93	-0,29	-1,10
ee	[0,36]	[0,52]	[0,19]	[0,23]	[0,37]	[0,49]	[0,27]	[0,18]	[0,18]	[0,09]	[0,40]	[0,34]
t	(-4,50)	(-1,71)	(-2,41)	(-6,57)	(-3,77)	(-1,30)	(-2,57)	(-8,14)	(-6,57)	(-9,93)	(-0,73)	(-3,28)
xpib		-0,68				-0,66				-0,27		
ee		[0,37]				[0,28]				[0,04]		
t		(-1,85)				(-2,38)				(-6,35)		
til			2,26				1,39				5,47	
ee			[0,63]				[0,56]				[1,32]	
t			(3,58)				(2,47)				(4,15)	
th				0,05				0,10				0,23
ee				[0,02]				[0,03]				[0,10]
t				(2,88)				(3,46)				(2,27)
R^2	0,96	0,93	0,97	0,96	0,94	0,94	0,94	0,92	0,65	0,88	0,53	0,50
F-stat	88,11	60,07	96,94	90,69	50,16	58,30	55,26	46,88	25,29	26,98	10,21	11,63
J-stat (prob.)	0,82	0,32	0,10	0,14	0,96	0,47	0,98	0,72	0,08	0,57	0,51	0,10

Fuente: Elaboración propia. Redondeamos los resultados a dos decimales.
ee = error estándar.
t = t estadístico.

5.2. Regresiones de sección cruzada

Por último, estimamos el siguiente modelo de sección cruzada para G1 y G2, que es la única estructura de datos que nos permite incorporar el Índice de Estado de Derecho del año 2018 como regresor:

$$TCPEM_i = c + \beta_1 * tmgp_i + \beta_2 * ied_i + \varepsilon_i \quad (3)$$

Donde: TCPEM es el crecimiento medio de PEM (2008-2018); *tmgp* es el logaritmo del promedio aritmético de TMGP (2008-2018), *ied* es el logaritmo del Índice de Estado de Derecho del 2018 (WJP, 2018), *i* refiere a las entidades federativas que para G1 = 22 y para G2 = 8.

A la ecuación anterior le agregamos la *dummy* DUM solo en G1, que captura el efecto de los estados con las reducciones más altas de PEM (Baja California Sur, Nuevo León y Tlaxcala).

Acorde con la práctica econométrica sugerida en artículos seminales acerca de pobreza (Mauro, 1995, 1996, 1998, 2002), que también emplean datos de sección cruzada y estiman con técnicas de variables instrumentales, atendemos la posible endogeneidad con GMM (Hansen, 1982). Además, usamos la matriz HAC (Newey y West, 1986) para así obtener t-estadísticos asintóticamente eficientes y residuos blindados contra autocorrelación serial y heterocedasticidad. Esta técnica deriva de los modelos desarrollados por Hansen (1982), que consideran (implícita o explícitamente) racionalidad de los agentes, lo que justifica su uso en la hipótesis del *efecto cobra*, ya que refleja la racionalidad de todos los participantes en los programas sociales, quienes ante un estímulo (política social) y ante la falta de oportunidades de superación socioeconómica, tienen conductas que generan resultados opuestos a los objetivos.

Al igual que MCO2E, GMM también exige la correcta selección de instrumentos (Z_i) que estén relacionados con los regresores y no con los residuos. En este sentido, Wooldridge (2001: 92) señala que "siempre que las variables estén relacionadas con los regresores endógenos, podemos utilizar las variables exógenas excluidas como instrumentos". De nueva cuenta, esto lo verificamos con el estadístico J.

Los instrumentos fueron elegidos en virtud de que elevaron la significancia estadística de los parámetros y la bondad de ajuste y generaron parámetros económica y estadísticamente coherentes.

Usamos como instrumentos el número de empleados en el sector secundario, su productividad media y el número de empleados en el sector terciario, que es en donde Deaton (2013) y CEPAL (2012) reportan el origen de las condiciones de ocupación más precarias, debido a instituciones débiles que no protegen los derechos laborales de los trabajadores. También agregamos la tasa de desempleo y de informalidad laboral; destacando que la primera ha reportado niveles bajos en virtud de que la segunda ha sido alta, lo que se debe a las instituciones que no han atendido los rezagos del mercado de trabajo (CEPAL, 2012 y 2016).

Otro instrumento es la pobreza moderada multidimensional, que es mayor a la pobreza extrema multidimensional y, por tanto, puede estar influyendo mucho en la asignación de recursos sociales a los estados. También agregamos la población estatal en virtud de que su ritmo de crecimiento es mayor al de la actividad económica, lo que sugiere que los frutos del crecimiento se reparten heterogéneamente (Banerjee y Duflo, 2012). Por último, incorporamos el Índice de Orden y Seguridad (IOS) y el Índice de Ausencia de Corrupción (IAC) del 2018 que son los componentes del Índice de Estados de Derecho que más se han deteriorado en México (WJP, 2018).

De esta estrategia se obtuvieron los siguientes resultados para G1 y G2, ecuación (4) y (5), respectivamente:

(4) $$TCPEM_i = -39{,}16 - 1{,}48 * tmgp_i - 41{,}44 * ied_i + 4{,}98 * DUM + \varepsilon_i$$

ee	[4,24]	[0,45]	[3,98]	[1,04]
t	(–9,23)	(–3,29)	(–10,41)	(4,79)

$R^2 = 0{,}82$; J-estadístico = 1,91(0,86).

(5) $$TCPEM_i = -33{,}87 + 3{,}01 * tmgp_i - 15{,}97 * ied_i + \varepsilon_i$$

ee	[5,65]	[1,04]	[4,47]
t	(–5,99)	(2,89)	(–3,57)

$R^2 = 0{,}12$; J-estadístico = 2,39(0,66).

De acuerdo con estos resultados, puntualizamos lo siguiente:

1. Los grados de libertad en G1 son 18 y en G2 solo 5, lo que eventualmente podría cuestionar los resultados en este último grupo; sin embargo, consideramos que son sumamente importantes en cuanto a que complementan eficientemente la inferencia de los modelos anteriores.
2. El estadístico J y su probabilidad indican que los Z_i son adecuados y cumplen la condición de ortogonalidad en ambos grupos y la bondad de ajuste en G1 es notablemente mayor, lo que podría asociarse a los grados de libertad.
3. La constante en G1 es menor que la de G2 (-39,16 *vs* -33,87), lo que prueba mejores resultados de un conjunto de variables de desarrollo en la reducción de PEM.
4. Nuevamente mostramos evidencia rotunda de que *tmgp* perpetúa *pem* en G2 por el signo y significancia de su parámetro asociado (3,01), contrario a G1 (-1,48).
5. Por último, encontramos que *ied* arroja parámetros significativos, negativos y los más elevados, que lo confiere como un importante instrumento de política, quizá el más importante de combate a PEM. Destaca que es mayor en G1 que en G2 (-41,44 *vs* -15,97).

6. Análisis y discusión de resultados

La frecuencia bienal y el corto periodo de nuestros datos (2008-2018) impiden el uso de técnicas VAR o RCT y ello nos condujo a estimar con paneles cortos; es decir, tener más individuos (30 estados) que observaciones (6). No obstante, las técnicas usadas y nuestros resultados son consistentes con la literatura empírica y teórica de los determinantes de la pobreza y con el carácter erróneo de las políticas asistencialistas documentado en la literatura.

Además, si bien las secciones transversales analizados por otros autores son personas beneficiarias de programas sociales (RCT), aquí demostramos que al hacerlo con estados y regiones llegamos a resultados complementarios, nunca excluyentes, que contribuyen a la discusión de este importante tema, ya que nuestro enfoque (con estados y no personas) permite identificar variables exógenas a los programas sociales que están perpetuando la pobreza y aquellas que pueden erradicarla en favor de los objetivos del desarrollo.

Un primer gran resultado se refiere a que el signo positivo y estadísticamente significativo del coeficiente de *tmgp* en todos los modelos de G2 (panel y de sección cruzada) nos permite afirmar contundentemente que las políticas del gobierno actual (2018-2024), basadas en incrementos notables del gasto asistencial (con fines electorales/clientelares) a expensas de reducir otras partidas importantes para el crecimiento y el desarrollo de largo plazo como es el gasto de inversión (SHCP, 2019), seguramente no disminuirán la PEM.

En este sentido, Kray y Raddatz (2007) encuentran evidencia empírica de que el gasto en pobreza no incrementa la productividad total de los factores (único motor de crecimiento económico de largo plazo y, por tanto, crucial para erradicar la pobreza), por lo que es plausible considerar que los incentivos perversos de los programas sociales en G2 seguirán generando los mismos resultados (Siebert, 2001). Barro (1991) estima que el gasto corriente del gobierno (que es el rubro donde se contabilizan las transferencias monetarias a la pobreza) está inversamente relacionado con el crecimiento económico en un amplio grupo de países, incluido México, ya que esos programas son financiados a partir del sacrificio de la inversión pública.

Nuestro segundo resultado más importante en términos de la hipótesis del *efecto cobra* es la evidencia de que existe dependencia en sección cruzada de acuerdo con la prueba de Pesaran (2004), que sugiere que las transferencias de algunas entidades afectan la pobreza de otras. Es decir, las familias en pobreza extrema tienen incentivos para migrar hacia las entidades que destinan mayores recursos al gasto social e incurrir crecientemente en conductas perversas, complicando los resultados en G1 y G2.

De acuerdo con Ramones y Prudencio (2014), es posible que un sector importante de la población opte por abandonar sus empleos (informales, precarios y con bajos salarios) a cambio de participar en actividades delictivas o sobrevivir con los beneficios de los programas sociales, fomentando así la improductividad y la dependencia intergeneracional de los recursos públicos, perpetuando así su condición de pobreza. En este sentido, es muy probable que los incentivos

perversos ya sean parte de la cultura de la pobreza en México (Lewis, 1959), en que las familias pobres tienen sentimientos profundos de desánimo y frustración, que les evitan a cambios de conducta.

En la medida en que los coeficientes de la productividad laboral del sector primario son negativos, estadísticamente significativos y mayores en G2, comprobamos que las familias en pobreza extrema multidimensional se concentran en las regiones donde la actividad agrícola es preponderante en la generación de producto y empleo, que se asocia a mayor marginalidad.

Las políticas que incrementan la productividad de la agricultura que, de acuerdo con Deaton (2013), genera rendimientos crecientes y efectos positivos (derrames) a todo el sistema económico podrían traducirse en resultados virtuosos de reducción de la pobreza multidimensional.

Finalmente, con los modelos de sección cruzada demostramos la enorme importancia del Estado de Derecho en los dos grupos, al grado en que podría convertirse en el instrumento más eficiente de combate a la pobreza.

7. Conclusiones, comentarios finales y recomendaciones de política

El año 2015 fue la fecha límite que estableció la ONU (2010) para cumplir el *Primer Objetivo de Desarrollo del Milenio* y, al término de esa iniciativa, la ONU (2015b) en su agenda para 2030 fijó como *Primer Objetivo del Desarrollo Sostenible* eliminar la pobreza extrema por ingresos.

La metodología multidimensional de la pobreza extrema que aquí usamos indica que mayores transferencias monetarias asistenciales podrían estabilizar el consumo de alimentos en el corto plazo, pero no solucionar los problemas estructurales que generan la trampa de pobreza.

Probamos la hipótesis del *efecto cobra* en México, referida a que las transferencias monetarias incrementan la pobreza extrema multidimensional en los estados más pobres (G2), que es el grupo constituido por ocho estados caracterizados por los peores resultados de desarrollo e institucionalidad, suceso que no ocurre en G1 (estados más desarrollados). Además, asociamos este resultado a la menor adhesión al Estado de Derecho en G2, en donde los incentivos perversos, la corrupción y la violencia han distorsionado el verdadero objetivo de los programas sociales, además de generar diversas externalidades negativas que disminuyen la inversión y el crecimiento económico (Mauro, 1995).

Estos hallazgos empíricos proponen un cambio radical a las políticas asistencialistas tradicionalmente aplicadas y que ahora han tomado un sello característico del gobierno mexicano (2018-2024). Un primer cambio crucial en este sentido sería focalizar los esfuerzos fiscales hacia las comunidades rurales en los términos sugeridos por Deaton (2013) y Banerjee *et al.* (2015).

La coordinación de estas políticas es el núcleo central de las propuestas de Banerjee *et al*. (2015) que están diseñadas para aplicarse en las comunidades urbanas y principalmente las rurales, dejando en un papel marginal (de

estabilización del consumo básico) a las transferencias monetarias y elevar sustancialmente el gasto público de inversión. Es probable que los estados con menor pobreza (G1) hayan adoptado estas políticas, aunque la meta de erradicación de la pobreza parece aún más lejana si consideramos los estragos que ha provocado la coronacrisis.

Probamos que, en concordancia con la hipótesis de heterogeneidad estructural de CEPAL (2016) en México, las exportaciones, la informalidad y los homicidios dolosos determinan la pobreza extrema multidimensional y nuestra agrupación responde adecuadamente a las diferencias de estas variables entre estados. Los estados comprendidos en G1 se caracterizan por sus sectores más intensivos en capital y en tecnología, lo que ha generado mayor valor agregado y mercados más vinculados con el sector externo y la formalidad. Por otro lado, demostramos que el resto del país (G2) es muy homogéneo en términos de que se encuentra en una trampa de pobreza retroalimentada por los altos índices delictivos, menor calidad de sus instituciones y el persistente gasto público asistencial.

Para revertir la situación antes descrita, es crucial y urgente que el gobierno mexicano fomente el crecimiento económico y la adhesión al Estado de Derecho y corrija diametralmente la orientación asistencialista y electoral que ha caracterizado a sus programas sociales en favor de elevar el gasto de inversión e impulsar la autosuficiencia e independencia de los pobres de los programas asistenciales.

A manera de corolario, habría que decir que más no necesariamente es mejor que menos. Aquí demostramos que la estrategia de combate a la pobreza con mayores transferencias monetarias es un buen ejemplo y que las políticas sociales focalizadas desde varios ejes económicos, sociales y de Estado de Derecho podrían atacar la trampa de pobreza en la que se encuentra una buena parte de los estados de México.

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Anexos

TABLA 1A
DESCRIPCIÓN Y DEFINICIÓN DE VARIABLES

Acrónimo	Concepto	Definición	Fuente
PEM	Pobreza Extrema Multidimensional. Es la variable dependiente en todos nuestros modelos econométricos.	Se publica bienalmente desde 2008 y hasta 2018. Mide el porcentaje de la población que carece de tres o más de los siguientes seis servicios: educación, salud, seguridad social, calidad y espacios de la vivienda, servicios básicos en la vivienda y acceso a la alimentación, además de tener un ingreso total insuficiente para satisfacer sus necesidades básicas alimentarias y no alimentarias.	CONEVAL (2020a), organismo público encargado de medir la pobreza extrema por ingresos y por carencias sociales en México.
TMGP	Transferencias Monetarias del Gobierno a los Pobres.	En México no existen series estadísticas oficiales ni integradas a nivel nacional ni por estados de transferencias monetarias del gobierno a los pobres, por lo que las construimos con base en la cuenta pública de cada estado por año, que presenta el grueso de información del gasto público por ramos (salud, educación, seguridad pública, desarrollo social, además de otros 35 rubros). Tomamos información sobre las transferencias monetarias a los pobres, que solo están disponibles desde 2008. La SHCP (2020) etiqueta estos datos como transferencias monetarias que destina la Secretaría de Desarrollo Social (ahora Secretaría del Bienestar) a las familias, agricultores, artesanos tradicionales, desempleados y jornaleros rurales que viven en condiciones de pobreza y en comunidades marginadas. Estos destinos de las transferencias se presentan por separado en la cuenta pública, por tanto, los sumamos para obtener el total de las transferencias a los pobres. Repetimos todo este proceso para cada estado y para el total nacional por año y deflactamos las series con el INPC (base 2013).	Construido con datos de SHCP (2020) e INEGI (2020).
PMM	Pobreza Moderada Multidimensional.	Porcentaje de la población que carece de menos de 3 servicios.	CONEVAL (2020a).

Acrónimo	Concepto	Definición	Fuente
PEI	Pobreza Extrema por Ingresos.	Corresponde al % de la población cuyo ingreso diario es menor o igual a US$ 1.9.	Banco Mundial (2020).
Y	PIB real estatal en millones de pesos constantes de 2013.	Es la suma de Y del sector primario (YP), del secundario (YS) y del terciario (YT).	INEGI (2020).
E	Número de personas ocupadas.	Es la suma de E del sector primario (EP), secundario (ES) y terciario (ET).	
YL	Productividad media laboral.	Es el cociente Y/E.	
YLP	YL del sector primario.	YP/EP	
YLS	YL secundario.	YS/ES	
YLP	YL terciario.	YT/ET	
TIL	Tasa de Informalidad Laboral	Ocupados laboralmente vulnerables por la naturaleza de la unidad económica para la que trabajan y aquellos cuyo vínculo laboral no es reconocido por su fuente de trabajo.	INEGI (2020).
XPIB	Exportaciones totales de mercancía como % del PIB estatal.	Mercancías que salen del territorio nacional de forma definitiva o temporal mediante un pedimento aduanero.	
POB	Número de habitantes.	Población a mitad del año.	
TCCO	Tasa de Condiciones Críticas de Ocupación.	Porcentaje de la población ocupada que se encuentra trabajando menos de 35 horas a la semana por razones de mercado, más la que trabaja más de 35 horas semanales con ingresos mensuales inferiores al salario mínimo y la que labora más de 48 horas semanales ganando hasta dos salarios mínimos.	
u	Tasa de desempleo.	Porcentaje de la población económicamente activa.	
X	Exportaciones en miles de dólares corrientes.	Exportaciones de manufacturas.	
YPC	PIB *per cápita* en millones de pesos constantes de 2013.	Es el cociente Y/POB	Cálculos propios con datos de INEGI (2020).

Acrónimo	Concepto	Definición	Fuente
TH	Tasa de homicidios dolosos por cada 100 mil habitantes.	*Proxy* del grado de violencia asociada el deterioro del Estado de Derecho.	Cálculos propios con datos de SESNSP (2020) e INEGI (2020).
TE	Tasa de extorsiones por cada 100 mil habitantes.	Obligar a otro a dar, hacer, dejar de hacer o tolerar algo para obtener un lucro o causando un perjuicio patrimonial.	
TS	Tasa de secuestros por cada 100 mil habitantes.	Retener por la fuerza o por engaño a una persona o a un grupo de personas, generalmente con el propósito de extorsión económica o de beneficio económico en contra de la víctima o de una tercera persona.	
ILABPC	Ingreso laboral *per cápita*, millones de pesos constantes del 2010.	CONEVAL la obtiene deflactando el ingreso laboral *per cápita* en pesos corrientes con el INPC (base 2010).	CONEVAL (2020c).
IED	Índice de Estado de Derecho del 2018. Se construye de la percepción ciudadana.	World Justice Project (2018: 7) mide el IED en México a partir de una encuesta realizada a 25.600 habitantes del país, 800 por cada entidad federativa, a quienes se les pregunta su percepción acerca de 8 "principios institucionales" que lo conforman: corrupción, derechos fundamentales, orden y seguridad, justicia civil, justicia penal, cumplimiento regulatorio de las autoridades púbicas, gobierno transparente o abierto y límites al poder gubernamental. Esto genera un índice por cada "principio", cuya escala va de 0 a 1, donde 0 indica total desapego al principio institucional y 1 indica perfecta adhesión. El promedio aritmético de los 8 índices es igual al IED	WJP (2018).
IAC	Índice de Ausencia de Corrupción del 2018.	Mide si las autoridades públicas utilizan su poder e influencias para beneficio propio. Es el principio institucional más rezagado de todos (más cercano a 0).	
IOS	Índice de Orden y Seguridad del 2018	Mide si el Estado es efectivo en garantizar la seguridad de las personas y la de sus propiedades. Es el segundo principio más rezagado.	

Fuente: Elaboración propia.

TABLA 2A
PRUEBAS DE RAÍZ UNITARIA

		PEM		TMGP		Y		YLP	
		Nivel	Δ	Nivel	Δ	Nivel	Δ	Nivel	Δ
TI	t	-17,8	-25,8	-9,4	-26,7	-24,9	-21,6	-15,7	-708,0
	prob.	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)
C	t	-1,9	-21,0	-15,8	-14,9	2,4	-23,8	-4,1	-17,7
	prob.	(0,03)	(0,00)	(0,00)	(0,00)	(0,99)	(0,00)	(0,00)	(0,00)
N	t	-6,9	-11,0	-25,3	-9,8	16,3	-3,6	1,6	-14,5
	prob.	(0,00)	(0,00)	(0,00)	(0,00)	(0,99)	(0,00)	(0,95)	(0,00)
		XPIB		TIL		TH			
		Nivel	Δ	Nivel	Δ	Nivel	Δ		
TI	t	-15,12	-28,39	-15,49	-66,41	-10,69	-28,15		
	prob.	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)		
C	t	-1,39	-17,08	-3,54	-11,54	-3,00	-11,40		
	prob.	(0,08)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)		
N	t	7,01	-8,87	-1,39	-11,35	2,78	-11,35		
	prob.	(0,99)	(0,00)	(0,08)	(0,00)	(0,99)	(0,00)		

Nota: Se aplicó la prueba de raíz unitaria común de Levin, Lin y Chu (2002), Ho: ∃ *raíz unitaria común*.
Aplicamos el procedimiento de Dolado *et al*. (1990) para las pruebas de raíz unitaria desde la más irrestricta a la más restricta, donde TI = tendencia e intercepto, C = constante y N = ninguna.
A pesar de que las únicas variables en donde no podemos rechazar Ho son Y y XPIB con C y N, probamos que con TI sí podemos rechazarla; por lo que de acuerdo con el supuesto de que la estacionariedad es más relajada en los micropaneles por EF, EP y EA (Baltagi, 2005: 237), concluimos que todas las variables de la tabla son I(0).

TABLA 3A
PRUEBAS DE ORTOGONALIDAD

Instrumento	G1		G2	
	Diferencia del estadístico J	Prob.	Diferencia del estadístico J	Prob.
ET	1,17	0,28		
ES			0,00	0,98
PMM	0,32	0,57		
TIL	0,21	0,65		
YLS	0,35	0,56		
POB	1,19	0,28		
X	1,23	0,27	0,03	0,87
IOS	0,10	0,75	0,10	0,76
IAC			0,14	0,71
u			0,23	0,88

Fuente: Elaboración propia. Ver definiciones en la tabla 1A.
[a] Ho: Z_i es ortogonal.

Pollution, green union, and network industry*

Contaminación, sindicato verde e industria de redes

Luciano Fanti**
Domenico Buccella***

Abstract

In a network industry, this paper investigates the impact of network effects on total pollution under the presence of a union interested to "local" environmental damages (e.g., polluting production processes damaging workers' health and the local environment where workers live). Under monopoly, it is shown that, on the one hand, network effects tend to increase the investments in the cleaning technology but, on the other hand, increase the polluting output; consequently, the effects on the total pollution are ambiguous. We also find that total pollution reduces (increases) with increasing network effects intensity if the market is sufficiently large (small). Moreover, the pollution-reducing result of increasing network effects appears when the existing network effects, the union's environmental concerns and the technological efficiency are sufficiently large. These findings are qualitatively confirmed under Cournot duopoly, offering empirical, as well as policy, implications.

Key words: *Network goods, Cleaning technology, Pollution production, Green Unions, Monopoly, Cournot duopoly.*

JEL Classification: *J51, L12, Q52.*

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** Department of Economics and Management, University of Pisa, Via Cosimo Ridolfi, 10, I –56124 Pisa (PI), Italy. E-mail address: lfanti@ec.unipi.it; tel.: +39 050 22 16 369; fax: +39 050 22 16 384.

*** (Corresponding author), Department of Economics, Kozminski University, Jagiellońska Street, 57/59 – 03301 – Warsaw, Poland. E-mail: buccella@kozminski.edu.pl; tel.: + 48 22 51 92 153.

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Resumen

Este documento investiga el impacto de los efectos de la red en la contaminación total bajo la presencia de un sindicato interesado en los daños ambientales "locales" (por ejemplo, contaminar los procesos de producción que dañan la salud de los trabajadores y el medio ambiente local). En régimen de monopolio, se demuestra que, por una parte, los efectos de red tienden a aumentar las inversiones en la tecnología de limpieza pero, por otra, a aumentar la producción contaminante; en consecuencia, los efectos sobre la contaminación total son ambiguos. También encontramos que la contaminación total se reduce (aumenta) con el aumento de la intensidad de los efectos de red si el mercado es lo suficientemente grande (pequeño). Estos hallazgos se confirman cualitativamente bajo el duopolio de Cournot, ofreciendo implicaciones empíricas y políticas.

Palabras clave: *Bienes de red, Tecnología de limpieza, Producción de contaminación, Sindicatos Verdes, Monopolio, Duopolio de Cournot.*

Clasificación JEL: *J51, L12, Q52.*

1. Introduction

The growing relevance of network industries and their fast, constant development is, up to the current stage, one of the most significant stylized fact in contemporary economics. One may simply think the large-scale expansions of devices such as mobile phones and tablets, and computer software. It is immediate to recognize that the utility a single consumer gets from using those goods increases with the number of other users. Noteworthy several companies in network industries produce and assembly their final products in large manufacturing plants (e.g. the several times mentioned in the media Apple's Foxconn plant in China) which, in most of the cases, adopt polluting production processes generating highly pollutant local emissions.

As a consequence, the topic of environmental safety has become of great importance on the political as well as popular debate in several industrialised countries. In those countries, the presence of trade unions in imperfectly competitive markets, mainly monopolies and oligopolies, is widely observed (Booth, 1995). The present paper aims to answer the following research question: in a network industry with the presence of an environmentally oriented union, may the intensity of the network effect reduce total pollution?

To study the subject of environmental safety is crucial because workers are the most exposed to pollution damages, in the dual role of people participating in the production process and inhabitants living close to the polluting plant. Up to date, not much attention has been devoted to the role organised workers, in the form of a union, play in such polluting milieu.

Workers were interested in improving their working place in some critical industries, for instance those at contact with asbestos, a cancer-causing agent; they were collectively asking for more protection and this happened prior to the embeddement of environmental issues in the bargaining agenda (Henri, 2007). In fact, in recent years, it has been observed, at least in well-identified industries, the rise of "green unions", i.e. unions that have environmental concerns and increasingly interested to "Work Health and Safety" (for a discussion, see e.g. UNEP, 2008, 2011; ILO and UNEP, 2012; ILO, 2013; ITUC, 2014a), and to promote a "*Green collective bargaining"* which includes the climate change issue during the negotiation processes at the workplace and collective level to tie environmental solutions to social commitment to remodel the economic efficiency of innovative organizations (EPSU, 2017). For example, with regard to the issue of working in a safe and healthy environment, in 2014, after a five-month campaign led by environmental labour unions and actionists, Apple decided to remove extremely toxic chemicals (including benzene and n-hexane) from its supplier factories in China. The hi-tech multinational announced that it will "explicitly prohibit the use of benzene and n-hexane" at 22 of its final assembly supplier factories employing nearly 500,000 workers (ITUC, 2014b).

Other examples, related to the issue of carbon emissions reduction, are the following. Unions at British Telecom (BT), through the Trade Union Congress' national GreenWorkplaces Project, put in place an action to "green" the Adastral Park, BT's research and development headquarters. The main objective is to reduce the Park's environmental (carbon footprint) impact (TUC, 2010).

Environmental issues at Électricité de France (EDF), in 2009 the world's largest producer of electricity, are widely discussed by trade unions at every level, from global to national. EDF operates in several countries: in some of them, as a significant player; in France, almost as a monopolist.[1] In January 2005, EDF signed a global agreement with unions on Corporate Social Responsibility (CSR). In UK, the EDF Company Council is the main union/management consultation body devoted to raise environmental questions; however, regular (quarterly) meetings are also arranged with CSR delegates from the four active unions (GMB, UNISON, Prospect and Amicus, now Unite), to discuss and review sustainability issues and goals. The agreement signed in 2005 covers areas such as fundamental rights, employee relations, community responsibilities, relations with subcontractors. Concerning the environment, EDF committed to guarantee the safety of its facilities to protect local and wider communities, to take model actions in the environmental area, and to promote energy efficiency for clients and within the group. In 2009, the agreement was revised, and the section on environmental issues was reinforced with precise references to counteracting climate change and reducing CO2 emissions. Nonetheless, this global agreement has a direct impact at national level: in fact, it requires that in each country "at a

[1] As of 2017, EDF retains 85.5% of France residential customers (Financial Times, 2018)

minimum" there must be "an annual written review" of progress, which should be sent to the employee delegates in charge of CSR monitoring (TUC, 2014).

The theoretical literature has mainly analysed the environmental damages involving all consumers and having, through transboundary effects, an international scale. Unexpectedly, the study of local/national damages has been mainly ignored in spite of the fact that: 1) a single giant plant can heavily damage the "local/national" environment while its "global" impact can be limited; and 2) the workers employed in polluting processes are, by and the large, the most affected people.

Clearly, the presence of active "green unions", via the inclusion of the environmental damage in the wage setting process, affects the output decision and, therefore, will have an impact on the total emission of the manufacturing plant. In a context with polluting giant plants, this means that workers are "selfish" in having preferences with environmental concerns[2] while consumers can be not damaged by pollution.[3]

The Industrial Organization literature has barely analysed the joint presence of unions and polluting firms (e.g., Barcena-Ruiz and Garzon, 2003, 2009; Barcena-Ruiz, 2011). Moreover, notwithstanding a vast sociological and political literature has documented the unions' sensibility to environmental problems, the study of labour unions caring about environmental safety has been largely neglected.[4] Exceptions are the contributions of Frederiksson and Gaston (1999) and, recently, Asproudis and Gil-Moltó (2015) and Fanti and Buccella (2017).[5]

Frederiksson and Gaston (1999) include labour market bargaining considerations in a framework with influence-seeking. Those authors show that a union's stance on environmental policy crucially depends on the exposure of its members to the risk of job loss. However, those authors do not focus their analysis on the impact of the union's environmental policy position on the industry outcomes.

In a unionised Cournot duopoly in which firms produce standard goods, Asproudis and Gil-Moltó (2015) investigate, from an industrial organisation perspective, the effects of unions having environmental concerns on firms'

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2 That is, labour unions are not motivated by ideological reasons, in line with the increasing wave of environmentalism, as some authors have documented by (e.g., Obach, 1999). Nonetheless, for simplicity, we keep here the definition of "green" unions.

3 This assumption is realistic. In fact, for example, workers and inhabitants of the polluted environment by a large manufacturing plant are infinitesimal with respect to the pool of all consumers.

4 For instance, Silverman (2006), Obach (1999) and the works quoted in Asproudis and Gil-Moltó (2015).

5 As the previously discussed EDF case suggests, this approach with environmentalist unions and firms' pollution abatements could be also related to another recent strand of industrial organization literature focusing precisely on CSR. In this regard, we can interpret, on the one hand, the unions' care for the environment as an example in which employees have social preferences and, on the other hand, pollution abatements as one reason for profit-seeking companies to invest in socially responsible activities. See Kitzmuller and Shimshack (2012), and Schmitz and Schrader (2015) for a recent literature survey on CSR.

decisions about cleaner technologies, output, and pollution levels. Those authors focus on the impact that alternative union structures, i.e., decentralized, and centralized union's wage setting, can have on firms' choices concerning "green" technologies. They show that a decentralized structure provides higher incentives for the investment in cleaner technologies, although emissions may be lower under a centralized structure. Moreover, the impact of the environmental damage parameter on wages and output can be non-monotonic.

Revisiting Asproudis and Gil-Moltó (2015), Fanti and Buccella (2017) investigate in a monopoly context whether and how the presence of a "green" union interested in "local" environmental damages (e.g., polluting production processes damaging workers' health and the local environment where workers live) affects the welfare of single agents –firms, consumers, and workers– and society as a whole. Those authors show that, under monopoly, the union's environmental concerns, depending on the market size, may incentivize or discourage the investments in cleaner technology and rather counter-intuitively, even increase the total environmental damage.

However, the above-mentioned authors study the presence of "green unions" in markets in which standard goods are produced. The main contribution of the present work is to introduce into the analysis the network effects, extending in this sense the framework of Asproudis and Gil-Moltó (2015). In particular, the analysis focuses both on the cases of monopoly and duopoly market structures. Moreover, we do not consider different wage settings in duopoly, but we restrict our attention to the centralized union wage setting in duopoly. In fact, our focus is on the relationship between the presence of network goods and green unions, and the level of total polluting emissions, which has remained so far unexplored.

As known, the network effect increases the consumers' demand and total output. Because the output is polluting, then a summary answer could be that pollution tends to increase. However, the analysis show that, if the network effects are adequately strong, they incentivize firms to adopt clean technologies and to abate more than the firms in standard industries studied by Asproudis and Gil-Moltó (2015). The net effect of the presence of network externalities on the industrial pollution is a priori ambiguous. We show that the answer crucially depends on the size of the product market. This is due to the non-linear effects of the interaction between the market size, on the one hand, and the firms' response to the network intensity in terms of adoption of cleaner technologies and production levels, on the other hand. In particular, the larger the market size is, the larger the differential between the incremental investment in cleaning technologies and the incremental production is (both due to the network effect), so that, for large enough market size, the pollution-reducing effect of the enhanced cleaning technology can outweigh the increased pollution due to the increased production.[6] These findings are qualitatively confirmed also under the Cournot duopoly.

[6] Note that the assumption of the clean technology adoption as a fixed cost investment (such as, for instance, an invention which makes the production process less harmful for

Therefore, these results offer some testable implications: for instance, higher pollution should be more frequently observed in industries with 1) low network effects rather than high network effects; 2) a small market dimension rather than a large market; 3) low environmentalist-orientation of the union rather than high environmental concerns. Moreover, it should be more often observed a pollution higher in small network markets than in small standard ones. For a Government interested in reducing the total pollution in network industries, the policy insight is to support the level of environmentalism of the green union.

The remainder of the paper is organised as follows. Section 2 introduces the monopoly model with green unions and network goods and presents the results of the analysis. Section 3 develops the duopoly model. Section 4 briefly discusses the policy implications. Section 5 brings the paper to its conclusion with some final observations and an outline of the potential future lines of research with regard to this subject.

2. The monopoly model

The simple network effects mechanism here assumed is that the surplus a firm's client obtains directly increases with the number of other clients of this firm (i.e. Katz and Shapiro, 1985).

Following Fanti and Buccella (2016) and Buccella and Fanti (2016), we assume that the monopolist firm faces the following linear inverse demand function:

$$p = a - q + ny \tag{1}$$

where q is the quantity of the goods produced, p is the price, y is the consumers' expectation about monopolist's equilibrium production, and the parameter $n \in [0,1)$ indicates the strength of the network effects (i.e., the higher the value of the parameter is, the stronger the network effects are).

In the spirit of the above discussion, to study the link between the presence of a "green" union and welfare outcomes we build a unionised monopoly model with polluting production. Therefore, we assume that there is a private monopoly which produces goods with a polluting production technology. Moreover, each unit of the goods produced generates k unit of pollutant, where $k \in (0,1]$. We also assume the availability of a cleaning technology for the firm, and a union with preferences for an environmental protection. However, following the pioneering model of Asproudis and Gil-Moltó (2015), remark that $k > 0$, that is, a technology that can eliminate emissions from production does not exist.

workers) explains the importance of the market size for the occurrence of the pollution-reducing effect.

Our assumptions related to the forms of the abatement cost function and the union's utility function strictly follow those of the established literature, and in particular the contribution of Asproudis and Gil-Moltó (2015).

The monopolist may cut emissions and selects its optimal level of pollution which requires a cost of pollution abatement (*CA*) assumed to be

$$CA = z(1-k)^2, z > 0 \tag{2}$$

The form of the *CA* function shows that the cleaner the technology is, the lower *k* is. Moreover, the adoption of cleaner technologies requires an increase in the fixed costs, and there are decreasing returns to the investment in technology, i.e. cutting down emission is always costly. Recalling that *k* is the pollution per unit of output, we may also say that a decrease (resp. an increase) of *k* is associated with a more (resp. less) efficient abatement technology, in the sense that the identical volume of polluting emission can be abated in a less (resp. more) expensive way. The parameter *z* up/downsize the total abatement cost and, therefore, it can be interpreted as a measure of the abatement technology's relative efficiency. The parameter *z* may be also understood as an exogenous index of technical progress. For example, a reduction of z can be exemplified by an exogenous shock such as the launch of a new and cheaper abatement technology.[7]

We assume that a union, having full power in the wage setting, is active in the monopolist firm. As usual, the traditional union (e.g., Pencavel, 1985) has the utility function $V = (w - w^{\circ})l$, where l represents the employment, w is the wage rate per unit of labour, and w° is the reservation wage. Given the assumption of constant returns to scale in labour, output and employment are equivalent, i.e. $q=l$.

This utility function exhibits the union's interest both for wage and employment. Nevertheless, the union may also care about the quality of the environment, as the examples reported in the Introduction inform us. Following Asproudis and Gil-Moltó (2015), the union is assumed to experience a decrease in its utility in the proportion *e* per unit of polluting emission. In other words, the parameter *e* represents the workers' marginal damage from pollution. Analytically, an additional term is introduced into the union's utility function to capture the idea of this environmental damage. Therefore, the union utility becomes:

$$V = (w - w^{\circ} - ek)q \tag{3}$$

In this regard, the parameter *e* is a measure of the relative union's orientation towards environmental safety, and the term *ek* in (3) can be interpreted as a non-constant reservation wage which increases in the externality work produces. To

[7] It can be immediately shown that, in equilibrium, the short-run average cost of pollution abatement positively depends on the parameter *z* in a way that, for example, if *z* is large, it can be quite costly to adopt highly "green" technologies.

ensure non-negativity on output, we assume that $a > e$. Moreover, as usual, and without loss of generality, we set $w^{\circ} = 0$ for analytical convenience.

The game follows this timing. At stage one, the monopolist selects the cleaning technology. At stage two, the union fixes wages. At stage three, following Katz and Shapiro (1985), the "rational expectations" realize, i.e., $y=q$. In the final stage, the monopolist chooses production (and employment), for given consumers' expectations. To obtain a subgame perfect Nash equilibrium, we solve the model making use of the backward induction method.

The monopolist profit function is

$$\pi = (a - q + ny)q - wq - z(1-k)^2 \tag{4}$$

At the fourth stage, the monopolist chooses the quantity to maximize profits, and the subsequent imposition at the third stage of the "rational expectations" condition, $y=q$, leads to the equilibrium quantities

$$q(w) = \frac{a-w}{2-n} \tag{5}$$

At the second stage, substituting (5) into (3), the union utility maximisation yields the wage rate:

$$w = \frac{a+ek}{2} \tag{6}$$

with $\frac{\partial w}{\partial a} > 0$, $\frac{\partial w}{\partial e} > 0$, and $\frac{\partial w}{\partial k} > 0$. The intuition behind these comparative statics are as follows. First, the higher the market size, the higher the consumers' willingness to pay; therefore, the union can fix a higher wage to catch a larger share of the monopoly rent. Second, the higher the environmental damage is, the higher the wage the union claims to compensate the disutility of pollution. Third, the cleaner the technology the monopolist uses, the lower the wage the union can claim as a compensation for the disutility caused by pollution (Asproudis and Gil-Moltó, 2015).

Making use of (5) and (6), at the first stage, the monopolist's profit maximisation with respect to the cleaning technology leads to the optimal emission intensity

$$k = \frac{4z(2-n)^2 - ae}{4z(2-n)^2 - e^2} \tag{7}$$

Substituting (7) backwards, the final equilibrium of the game in terms of output is

$$q = \frac{2z(2-n)(a-e)}{4z(2-n)^2 - e^2} \tag{8}$$

Total pollution, P, is given by

$$P = kq = \frac{2z(2-n)(a-e)\left[4z(2-n)^2 - ae\right]}{\left[4z(2-n)^2 - e^2\right]^2} \tag{9}$$

Recalling that $k > 0$, the conditions for a maximum as well as for the positivity of all variables boil down to the following set of inequalities:

$$\begin{aligned} &1)\ k > 0 \Leftrightarrow a < a^0 = \frac{4z(2-n)^2}{e} \\ &2)\ q > 0, \pi > 0 \Leftrightarrow e^2 < 4z(2-n)^2, e < a < a^0 \end{aligned} \tag{10}$$

By interpreting the parameter a as the size of the market, conditions (10) mean that this should be included in a range, i.e. the feasibility of the model's economy is restricted for a size sufficiently, though not excessively, large of the market. The following Remark follows.

Remark. The feasibility of the model's economy is reduced under network goods (relatively to standard goods), in the sense that it is required a smaller market dimension and a lower environmental interest of the union (as easily observed by the inspection of conditions (10)).

2.1. Results

In this section we investigate the influences of network goods on the adoption of cleaning technologies, production, and total pollution.

Lemma 1. *Both investment in the cleaning technology and output are increasing in the network effect (n) at an increasing rate.*

Proof: $\frac{\partial k}{\partial n} < 0, \frac{\partial^2 k}{\partial n^2} < 0, \frac{\partial q}{\partial n} > 0, \frac{\partial^2 q}{\partial n^2} > 0$.

This lemma shows that the network externality has two contrasting effects on pollution. In fact, the monopolist's emissions are given by $P = kq$, with both k and q that depend on the network effects, n: a positive impact on emissions via output expansion, but a negative impact on them via the monopolist's incentive to choose a "greener" technology. Despite the expansion of the polluting production, we are able to answer whether and how the network effect may reduce the industrial pollution.

The following total derivative easily shows the mechanisms through which network effects may be pollution-reducing:

$$\frac{dP}{dn} = \overset{+}{\overbrace{\frac{\partial q}{\partial n}}} k + \overset{-}{\overbrace{\frac{\partial k}{\partial n}}} q \, .$$

The above expression shows that the sign of the derivative crucially depends on the response of the monopolist in terms of production and cleaning technology to changes in the goods' network intensity.

Result 1. *The network effect always increases (resp. decreases) the total pollution in the case of small (large) values of a, that is small (large) market size. Moreover i) the higher the existing network effect is, the more likely an increase of its intensity may reduce total pollution; ii) the higher both the union's pollution concerns parameters and the technical progress index of the abatement technology (i.e. the lower z) are, the more likely is the occurrence of the pollution-reducing effect.*

Proof: the first part of Result 1 follows from $\frac{\partial P}{\partial n} \gtrless 0 \Leftrightarrow a \lessgtr a^* = \frac{4z(2-n)^2\left[4z(2-n)^2+3e^2\right]}{e\left[12z(2-n)^2+e^2\right]}$, where $a^* < a^0$; the second part is obtained from $\frac{\partial a^*}{\partial n} < 0, \frac{\partial a^*}{\partial z} > 0, \frac{\partial a^*}{\partial e} < 0$.

A first conclusion arising from Result 1 is intuitive: if the market size is not sufficiently large, the monopolist is not incentivised to invest in efficient cleaner technology. Consequently, the firm's total emission level is not reduced. Moreover, the presence of network externalities induces the firm to adopt a cleaner technology for a market size smaller than in an industry that produces standard goods.

Second, the derivative of the emissions with respect to the size of the network externality can be positive or negative depending on the strength of the network effect, *n*, provided that the market size is large enough. Specifically, there is a critical value of the size of the market a^* before (beyond) which emissions are increasing (decreasing) in the intensity of the network effect. The intuition behind this result is as follows. As the analytical inspection of total derivative $\frac{dP}{dn}$ shows, *n* has a positive effect on emissions via output expansion, but a negative effect via the technology choice. An increase in the network effects leads the monopolist to expand output which, as known, has a twofold impact on a firm's revenues. On the one hand, the positive direct effect due to the increase in production, and this leads to more emissions. On the other hand, there is the negative, indirect price effect. When the network

effects are strong, the negative price effect becomes relevant, and this second effect can outweigh the former; to increase profitability, the monopolist invests more in cleaning technologies which has the effect of reducing wages, and therefore reducing the operative costs.

Lemma 2. *Provided that* $a \geq a^*$*, the larger the market size is, the larger is the differential between the marginal benefit on the environment due to the investment in cleaning technologies and the marginal damage due to production expansion (both generated by the network effect).*

Proof: simple mixed derivatives drive the content of the lemma: $\left|\frac{\partial^2 k}{\partial n \partial a}\right| > \left|\frac{\partial^2 q}{\partial n \partial a}\right|$.

When the market size is sufficiently large, the increase in production levels due to the network effect, total pollution decreases thanks to the more intense investment in technologies related to pollution abatement. This contrasts with the common wisdom concerning the output expansion effect on pollution due to network externalities. Conversely, a small market size discourages investments in a cleaner technology because these are less profitable given the fixed cost nature of the adoption of a cleaner technology, and the small impact in reducing operative costs, i.e., wages.

Moreover, it is intuitive that the pollution-reducing result of a large network effect is more likely 1) when the union's perceived damage from pollution is higher because the latter tends to expand the pollution abatement (to moderate wages) and to reduce employment/output (or to increment employment/output less than the abatement), 2) when abating is cheaper.[8]

3. The duopoly model

In the next, we analyse a Cournot duopoly with differentiated product.[9] Following the established literature (for instance, Hoernig 2012; Chirco and Scrimitore, 2013; and Battacharjee and Pal, 2014), we consider a Cournot oligopoly with two unionized firms indicated by $i, j = 1,2$ with $i \neq j$ producing

[8] In the Appendix B, we have tested some extensions of the basic monopoly model. In particular we have considered 1) the case of a more general union utility function with different wage sensitivity. It has been found that if the network effect is weak, a wage oriented union leads to a relatively low pollution level than an employment oriented; the opposite holds true if the network effect is strong; 2) an environmental standard set by a social-welfare maximising Government: in this case, the key finding is that if the Government establishes the "environmental standard" then the total pollution is lower than when the firm selects it, and the network externalities significantly intensify the total pollution reduction effect. These models' specifications confirm the qualitative results obtained in the basic framework here presented.

[9] The analytical details are sometimes omitted to economize on space. Needless to say, the complete results are available from the authors upon request.

heterogeneous goods. We assume that each firm in this duopoly faces the following inverse linear direct demand:

$$p_i = a - q_i - \gamma q_j + n(y_i + \gamma y_j) \tag{11}$$

where q_i is the quantity of the goods produced by firm i, p_i is the price, y_i is the consumers' expectation about firm i equilibrium production, and the parameter $\gamma \in (0,1)$ indicates the degree of product substitutability.

Each firm i may reduce emissions and choose its optimal level of pollution which entails a cost of pollution abatement (CA_i) assumed to be

$$CA_i = z(1-k_i)^2, \;\; z > 0 \,. \tag{12}$$

We assume a centralised union,[10] which monopolistically fixes a uniform wage for workers of both firms. Keeping in-altered the motivations and simplifications discussed in the previous section for the monopoly case, the industry-wide union's utility function in the duopoly context becomes:

$$V = wq_i + wq_j - ek_iq_i - ek_jq_j \,. \tag{13}$$

The timing of the game is as follows. In the first stage, each firm non-cooperatively chooses the cleaning technology. In the second stage, the industry-wide union sets a common wage for both firms. The remaining stages are unaltered. We solve the game by backward induction to obtain a subgame perfect Nash equilibrium.

The profit function of firm i is

$$\pi_i = (a - q_i - \gamma q_j + n(y_i + \gamma y_j))q_i - wq_i - z(1-k_i)^2 \,. \tag{14}$$

At the last stage, the firm's profit maximisation with respect to the quantity leads to the following output level, as a function of the output expectations:

$$q_i = \frac{(a - w - \gamma q_j + n(y_i + \gamma y_j))}{2} \,. \tag{15}$$

[10] This assumption under duopoly is the most coherent with the case of monopoly firm, because in the case of firm-specific unions in duopoly also the strategic effect of the inter-union competition over the wages would has been introduced, thus potentially obfuscating the comparison between monopoly and duopoly regarding the relationship between network effects and pollution which is the focus of this paper. Of course, also the assumption of firm-specific unions (made for instance by Asproudis and Gil-Moltó, 2015, in their context) is worth to be explored in future works.

Solving the system composed by (15) and its counterpart for *j*, and imposing the "rational expectations" condition, $y=q$, the equilibrium quantities at the last stage are:

$$q_i(w) = \frac{a-w}{I}, \text{ where } I = 2-n+\gamma(1-n) \tag{16}$$

At the second stage, substituting (16) into (13), the following wage rate is obtained from the union utility maximisation:

$$w = \frac{2a+e(k_i+k_j)}{4} \tag{17}$$

Making use of (16) and (17), one gets the output as a function of the cleaning technology, and subsequent substitutions into (14) yields profits, again as a function of the cleaning technology

$$\pi_i(k_i,k_j) = \frac{\left[2a-e(k_i+k_j)\right]^2}{16I^2} - z(1-k_i)^2 \tag{18}$$

At the first stage, each firm *i*'s profit maximisation with respect to the level of the cleaning technology yields the following reaction functions in terms of the emission intensity

$$k_i(k_j) = \frac{e(2a-ek_j)-16zI^2}{e^2-16zI^2} \tag{19}$$

By solving the system composed by (19) and its counterpart for *j*, the following optimal emission intensity at the equilibrium is obtained

$$k_i = k_j = k^D = \frac{8zI^2-ae}{8zI^2-e^2} \tag{20}$$

where the upper script *D* denotes the duopoly case.

Comparing eq. (20) here with eq. (20) concerning the identical context in Asproudis and Gil-Moltó (2015), one can easily derive that $k_i^{NI} \leq k_i^{SI}$ *if* $n^T \geq \frac{1+2\gamma}{2(1+\gamma)}$, where "*NI*" stands for network industry while "*SI*" stands for standard industry. Note that the threshold value of the network effect, n^T, is independent of the market size, the union's orientation toward the environment, and technology efficiency. In other words, the presence of network externalities induces firms to invest more in cleaner technology if the network effects are adequately strong. The forces that lead to this result mirror those of the monopoly case.

Substituting (20) backwards, the final equilibrium of the game in terms of output is

$$q_i = q_j = q^D = \frac{4zI(a-e)}{8zI^2 - e^2} \tag{21}$$

Total pollution, P, is given by

$$P^D = 2k^D q^D = \frac{8zI(a-e)(8zI^2 - ae)}{\left(8zI^2 - e^2\right)^2} \tag{22}$$

A comparison of the emission levels per firm here (i.e. half of the value in the expression (22)) with those regarding the same framework in Asproudis and Gil-Moltó (2015), reveals that $k_i^{NI} q_i^{NI} \leq k_i^{SI} q_i^{SI}$ *if* $n \geq n^{TT}(a,e,\gamma)$, where the threshold value of the network effect, $n^{TT}(a,e,\gamma)$, has an extremely analytical complex form. To derive some qualitative conclusions, we have performed a set of numerical simulations, whose graphical analysis (see Appendix B) led to the following conclusions. When the cleaning technology is not efficient, the pollution network industries generate is higher than the one in standard industries. However, when the available "green" technology is efficient, then network industries pollute less than standard ones if the network externalities are adequately high.

The mechanism that leads to this result is like the one described above concerning the cleaning technology choice. When the cleaning technology is inefficient, the output expansion effect due to the network externalities yields high pollution levels. However, the technology inefficiency does not induce firms to adopt it to reduce wages: therefore, pollution remains relatively high. On the other hand, when the "green" technology is sufficiently efficient, when the network effects are strong, the negative price effect on revenues is relevant. Firms are incentivized to invest more in cleaning technologies; these lead both to the reduction of the firms' operative costs and emissions. Therefore, pollution can be lower than in standard industries, provided that the network effects are adequately strong.

Recalling that $k > 0$, the conditions for a maximum as well as for the positivity of all variables boil down to the following set of inequalities:

$$\begin{aligned} &i)\ k^D > 0 \Leftrightarrow a < a^{\circ D} = \frac{8zI^2}{e} \\ &ii)\ q^D > 0, \pi^D > 0 \Leftrightarrow e^2 < 8zI, e^{\circ D} < a < a^{\circ D} \end{aligned} \tag{23}$$

3.1. Results

The analysis of the effect of network consumption externalities on the adoption of cleaning technologies, production, and total pollution under a duopoly leads to the following results and considerations.

Remark. The feasibility of the duopoly model is enlarged with respect to that of monopoly under network goods (relatively to standard goods), in the sense that the duopoly is workable with a larger market dimension and a higher environmental interest of the union (as easily observed by $a^{\circ} < a^{\circ D}$, $e^{\circ} < e^{\circ D}$).

Preliminarily, we may compare the levels of polluting output and cleaning technology obtained under Cournot duopoly and monopoly, respectively.

Lemma 3. As expected, total quantity is larger under duopoly than monopoly, i.e. $2q^D > q$; however, firms invest more in cleaning technology under monopoly than duopoly, i.e. $k^D > k$.

Proof: The proof is straightforwardly obtained by comparison of the two values and omitted here for brevity.

The reason for the result that the unitary abatement of pollution is lower under duopoly is the following: i) at the intermediate stage, the union chooses the wage for given values of k_i, k_j, and the wage is increasing in both parameters; ii) therefore, since firms strategically choose their own level of k, each firm is less motivated to reduce its own pollution in order that the union reduces its wage claim because the latter reduction depends also on what will be the rival firm's choice of k. Moreover, the following holds.

Corollary 1: The higher the product differentiation is, the closer between them the investments in cleaning technology are; however, in any case, also with total product differentiation ($\gamma = 0$), it holds that $k^D > k$ (i.e., Result 1).[11]

This is because, when $\gamma \to 0$, firms tend to be independent, that is, to become two unrelated monopolies. However, although unrelated in the product market, firms remain related in the labour market. Indeed, the crucial role played by the wage setting in the choice of k under duopoly is witnessed also by the fact that each independent monopoly sets an investment in cleaning technology (for the same strategic reasons above mentioned) lower than in the case of a single monopolist. The rationale for this result is that the industry-wide wage depends

[11] The corollary follows by $\frac{\partial(k^D - k)}{\partial \gamma} < 0$ and $(k^D - k)\big|_{\gamma=0} > 0$.

jointly on (the sum of) the abatement choices, and it is unaffected by the degree of market competition.

While the above-mentioned facts (lower pollution abatement and large output in duopoly than monopoly) imply that the total pollution is always higher under duopoly than monopoly, the relationship between the network effect and the pollution remains qualitatively the same in both market structures. Indeed, from (20) and (21) it is easy to see that the network effect tends to increase both production and abatement of pollution, in line with the case of the monopoly, so that the effect of the network externalities on pollution is ambivalent also under duopoly. However, the following holds:

Result 2. *Under duopoly the network effect always increases (resp. decreases) the total pollution in the case of small (large) values of a, that is small (large) market size.*

Proof: Result 2 follows from $\frac{\partial P^D}{\partial n} \gtrless 0 \Leftrightarrow a \lessgtr a^{*D} = \frac{8zI^2(8zI^2+3e^2)}{e(24zI^2+e^2)}$.

As for the case of monopoly, if the market size is not adequately large, the duopolistic firms have no incentives to invest in "green" technologies, and therefore total emissions do not reduce. The forces at work that lead duopoly firms to make the output and abatement choices such that Result 2 arises mirror those of the monopolist firm in Result 1. However, a further analytical inspection reveals the next result.

Result 3. *The network effect induces a pollution reduction under duopoly when the market size is larger than under monopoly, that is* $a^* < a^{*D}$.

Proof: Result 3 follows from simple comparison.

As stated in the previous remark, the threshold value of the market size ensuring the feasibility of the model is larger under duopoly than monopoly and Result 3 is strictly connected to that finding. Overall, the parametric set for which the pollution-reducing effect appears is larger under duopoly than monopoly. Nonetheless, this difference shrinks with an increasing product differentiation: in fact, as goods become more differentiated, each firm acts like a monopolist for its own product. The intuition behind these findings is straightforward.

Total output in a duopoly industry is typically larger than in a monopoly due to the firms' rivalry. The presence of network effects pushes outward the duopoly firms' reaction functions, i.e., $\frac{\partial q_i(q_j)}{\partial n} > 0$, so that the equilibrium point is farther from the origin in the output space than in an industry with standard goods: the relevant market size increases. As for the monopoly, the total derivative $\frac{dP}{dn}$ reveals that *n* has a positive effect on emissions via output expansion, but a negative effect via the technology choice. An intensification of the network externalities induces

each firm to increase production which has a double impact on revenues: 1) the positive direct effect due to the increase in production, magnified by competition, and this leads to more emissions; 2) the negative, indirect price effect, also this magnified by increased competition. When network externalities are adequately strong, the negative price effect, now amplified by duopoly competition, becomes significant, and offset the direct output effect. As a consequence, to improve profitability, firms invest more in "green" technologies to curb the union's wage demand, and thus cut their operative costs.

Result 4. *Provided that the available technology is not extremely efficient: i) the network effect reduces pollution more under duopoly than monopoly; ii) the more differentiated the products are, the weaker the statement in part i) is.*

Proof: See Appendix A.

Concerning part i), the intuition behind this finding is that, in the presence of an efficient technology, the monopolist faces a substantial reduction in its "green" investment; moreover, it is more incentivized to choose higher abatement levels to reduce operative costs than a duopoly firm. As regards part ii) of Result 4, this finding is intuitive because the higher the product differentiation is, the more a duopoly tends to a monopoly. To sum up, the results discussed in the previous section for the case of a monopoly firm, are qualitatively confirmed also in the case of duopoly both with homogeneous and differentiated products.

4. Policy considerations and empirical implications

To derive some policy implications, we consider the case of a benevolent social planner whose aim is to maximize social welfare.

The social planner's optimization problem is to choose the output and the abatement level that maximize the following expression:

$$SW = \pi + V + CS$$

i.e., the sum of the monopolist profits, the union utility (which embeds the environmental damage) and the consumer surplus in the case of monopoly and

$$SW = \pi_i + \pi_j + V + CS$$

in the case of duopoly. As in Asproudis and Gil-Moltó (2015), we obtain that the social optimum is characterized by output and investment levels higher than the market ones (underproduction and underinvestment), with network externalities expanding these discrepancies.[12]

[12] Analytical details are available upon request from the authors.

However, the findings of this work suggest the following policy insights. If the government has the objective of improving the environmental quality through emissions reduction, it should prop up the demand facilitating the customers' access to the network of compatible products (e.g. in the case of telecommunications, installing repeaters in zones with feeble signal). This would expand the market size to such an extent that firms are incentivized to invest in "green" technologies, therefore reducing total pollution. Therefore, the government's interest would coincide with that of the environmentally oriented union. Moreover, the government should design the proper regulations to incentivize the firm's adoption of clean technologies.

Moreover, this work also suggests the following empirically testable implications: 1) in network industries, environmental unions should be broadly seen active in large plants serving adequately large markets; the role of the network externalities is that of increasing the relevant market size; and 2) in network industries with sufficiently intense externalities, the presence of "green unions" should induce firms having a large pool of consumers (that network externalities crucially contribute to expand) to allocate more resources for investments in "green" technologies than firms producing standard (i.e., no network) goods.

5. Concluding Remarks

In a network industry, this paper has investigated whether and how the intensity of the network effects affects the total pollution when in the manufacturing plant a union interested to "local" environmental damages, that is polluting production processes damaging workers' health and the local environment where workers live, is active. In the local monopoly model proposed, the paper has shown that, on the one hand, the network effects tend to increase the investments in the cleaning technology; however, on the other hand, network externalities increase the polluting output as well. Therefore, the impact of network externalities on the total pollution is in principle ambiguous. However, the analysis has shown under which conditions total pollution increases/decreases. We have shown that total pollution decreases (resp. increases) with an increasing intensity of the network effects if the size of the market is adequately large (resp. small) because, in this case, the incentivising (dis-incentivising) effect of adopting the cleaner technology outweigh the polluting effect due to output expansion. Moreover, it has been shown that the pollution-reducing result of the increasing network effects is more likely to appear when the existing network effects, the union's environmental concerns and the technological efficiency are adequately large. Therefore, given a government interested in reducing the total pollution in network industries, the policy insight is to give support to the environmentalism of the green union. The reference framework has been extended to a duopoly market structure with differentiated products. It has been shown that the network effect reduces pollution more under duopoly than monopoly, and the more the goods are differentiated, the weaker the reduction effect on pollution is.

To sum up, the qualitative findings of the basic model have been confirmed also under those extensions, providing a first robustness check.

Nonetheless, as future lines of research, the present model can be extended to *i)* a relaxation of the assumption that product substitutability is identical to product compatibility (Naskar and Pal, 2020); *ii)* consider the case of responsive expectations, that is, firms can commit to the level of their quantities because consumers believe that the announced level of quantities are equal to the actual network size (Katz and Shapiro 1985, Appendix A; Amir and Lazzati, 2011); *iii)* alternative modes of competition (Cournot vs. Bertrand), to investigate the condition under which different strategic contexts in the product market can change the results obtained under monopoly and Cournot duopoly; *iv)* an analysis of different bargaining agendas between the firm(s) and the union(s), relaxing the assumption of a monopoly union. Moreover, given that the workers' health risks are a main concern for the union, this issue may appear in the unions' bargaining agenda. Thus, the union could negotiate with firms about the clean technology; *v)* an analysis of different workers' pay systems such as the piece rate pay and the profit-sharing scheme, relaxing the assumption of a fixed wage system; *vi)* an investigation of how the organizational form of the company has an impact on total pollution (e.g. the presence of a manager to whom the firm's owners delegate decisions about the amount of sales/production levels and/or the adoption of cleaner technologies or the case for cross-ownership); *vii)* the analysis of the introduction of public policies such as tax/subsidy environmental policies.

Appendix A

A.1. Proof of Result 4, Part i)

To prove analytically part i) of Result 4, it suffices to evaluate, through the corresponding integrals in the (*n, a*) – space, the difference between the parametric areas below the curves $a^{\circ D} = \frac{8zI^2}{e}$ and $a^{*D} = \frac{8zI^2(8zI^2+3e^2)}{e(24zI^2+e^2)}$ under duopoly, and $a^0 = \frac{4z(2-n)^2}{e}$ and $a^* = \frac{4z(2-n)^2\left[4z(2-n)^2+3e^2\right]}{e\left[12z(2-n)^2+e^2\right]}$ under monopoly, respectively, and to show that the former area is larger than the latter one.

Let us define those differences as "Emissions Reducing Area" (ERA):

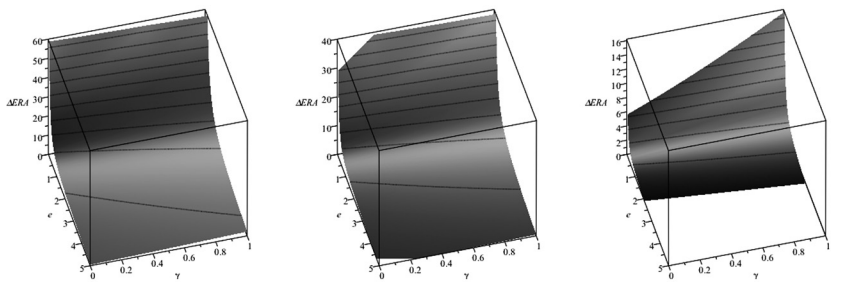

Fig. A1: Plots of the function ΔERA *in the plane* (*e*, γ)*, for different technological levels: left box,* $z = 1$*; center box,* $z = .5$*; right box,* $z = .1$*. Legend: grey area,* $\Delta ERA > 0$ *; white area,* $\Delta ERA < 0$.

$$ERA^D = \int_0^1 \frac{8zI^2}{e}dn - \int_0^1 \frac{8zI^2(8zI^2+3e^2)}{e(24zI^2+e^2)}dn =$$

$$-\frac{2}{27e\sqrt{e^2z(1+\gamma)^2}}\left(\begin{array}{l}-\left(\arctan\left(\frac{2z(2+\gamma)(1+\gamma)\sqrt{6}}{\sqrt{e^2z(1+\gamma)^2}}\right)-\arctan\left(\frac{2z(1+\gamma)\sqrt{6}}{\sqrt{e^2z(1+\gamma)^2}}\right)\right)e^4\sqrt{6}\\+12\sqrt{e^2z(1+\gamma)^2}\,(e^2-2\gamma^2z-10\gamma z-14z)\end{array}\right)$$

$$ERA^M = \int_0^1 \frac{4z(2-n)^2}{e}dn - \int_0^1 \frac{4z(2-n)^2\left[4z(2-n)^2+3e^2\right]}{e\left[12z(2-n)^2+e^2\right]}dn =$$

$$-\frac{4\left(e^3\sqrt{3}\arctan\left(\frac{2\sqrt{z}\sqrt{3}}{e}\right)-e^3\sqrt{3}\arctan\left(\frac{4\sqrt{z}\sqrt{3}}{e}\right)+6e^2\sqrt{z}-42z\sqrt{z}\right)}{27e\sqrt{z}}$$

where *D* and *M* stand for duopoly and monopoly, respectively. Let us also define $\Delta ERA = ERA^D - ERA^M \underset{<}{\geq} 0$. The analytical expression of ΔERA is not of direct

interpretation; however, graphical representations reported above indicate that there exists a critical threshold of $z < 1$, $z^T(\gamma, e)$ such that $\Delta ERA = 0$ in the relevant parametric space. For another visual inspection of Result 4, see also Section B.2.2 of Appendix B.

A.2. Proof of Result 4, Part ii)

Differentiating the expression of the emissions reducing area w.r.t. to the degree of product differentiation it is obtained

$$\frac{\partial ERA^D}{\partial \gamma} = \frac{1}{ez(1+\gamma)^3[e^2+24z(2+\gamma)^2]} \left(\begin{array}{l} -2[e^2+24z(2+\gamma)^2]e^2\sqrt{e^2z(1+\gamma)^2}\sqrt{6} \\ \left(\arctan\left(\frac{2z(2+\gamma)(1+\gamma)\sqrt{6}}{\sqrt{e^2z(1+\gamma)^2}} \right) - \arctan\left(\frac{2z(1+\gamma)\sqrt{6}}{\sqrt{e^2z(1+\gamma)^2}} \right) \right) \\ +24z[96(1+\gamma)(\gamma+\frac{5}{2})(2+\gamma)^2z^2+4e^2(1+\gamma)(\gamma+\frac{5}{2})z+e^4](1+\gamma)^2 \end{array} \right)$$

whose analytical expression is not of immediate interpretation; however, the graphical representations reported below indicate that the sign of derivative is positive provided that the value of the technological efficiency index is not too low. When the technology is efficient, there is a critical threshold of $z < 1$, $z^{TT}(\gamma, e)$ such that $\frac{\partial ERA^D}{\partial \gamma} = 0$ in the relevant parametric space.

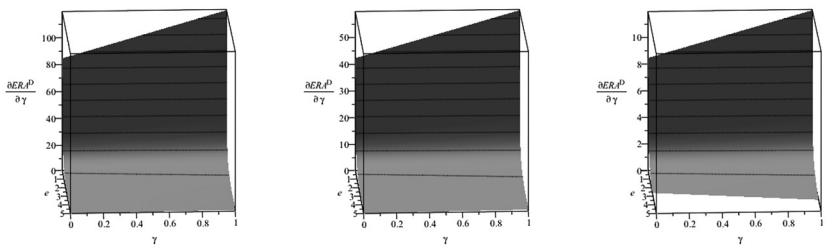

Fig. A2: Plots of the function $\frac{\partial ERA^D}{\partial \gamma}$ *in the plane* (e, γ)*, for different technological levels: left box,* $z = 1$*; center box,* $z = .5$*; right box,* $z = .1$*. Legend: grey area,* $\Delta ERA > 0$ *; white area,* $\Delta ERA < 0$.

Appendix B: Supplemental material

B.1. Numerical examples of Result 1

Result 1 is rather general and its quantitative implications may be illustrated with some examples (for a fixed $z=1$), as the two Figures below depict. In Figure B.1, the upper solid line represents the case with a relatively high value of $a=6$; the intermediate dashed line represents the case with a relatively intermediate value of $a=4.5$; the lower dotted line represents the case with a relatively low value of $a=3$. It is easy to see that for a market size relatively small the total pollution in the presence of increasing network effects either always increases or in any case remains always higher than that of the case of standard goods (i.e. $n = 0$) . On the other hand, if the dimension of the market is relatively ample the total pollution may decrease (for high enough network effects) significantly below that produced by industries with standard goods (and even below the level of pollution created by more small industries with the same level of network intensity).

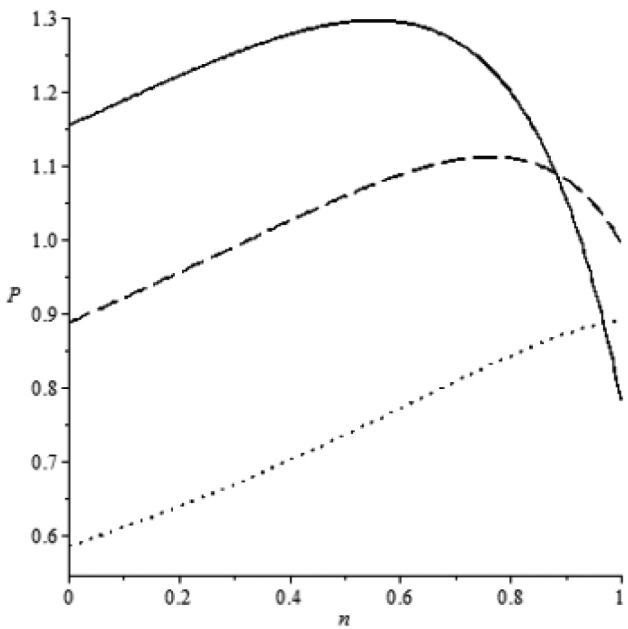

Fig. B.1. Total pollution, P, when the network effect (n) increases for three values of the market dimension (a), given e=0.5.

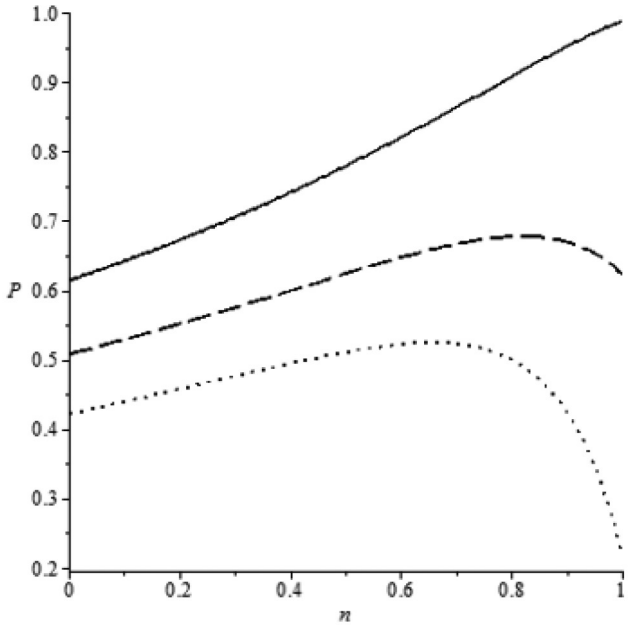

Fig. B.2. Total pollution, P, when the network effect (n) increases for three values of the union's environmental concerns (e), given a=3.

In Fig. B.2, the upper solid line represents the case with a relatively low value of *e=0.4*; the intermediate dashed line represents the case with a relatively intermediate value of *e=0.8*; the lower dotted line represents the case with a relatively high value of *e=1.2*. Fig. B.2 clearly shows that, in the case of a union rather lowly "environmentalist", the total pollution in the presence of increasing network effects either always increases or in any case remains always higher than that of the case of standard (without network externalities) goods, while if the union is adequately "environmentalist" the total pollution may decrease (for high enough network effects) significantly below that produced by industries whose goods are without network externalities.

B.2. Graphical representations duopoly model

B.2.1 A graphical representation of the emission levels per firm, network vs standard industries

To see which industry (network vs standard) generates a higher degree of pollution, we construct the following per-firm emissions' differential from equation (22) (divided by two) in the main text and the corresponding value in Asproudis and Gil-Moltó (2015, last expression in p.174):

$$\Delta P^{N,S} = \left(\frac{4 \cdot z \cdot \left(2 - n + \gamma \cdot (1-n)\right) \cdot (a-e) \cdot \left(8 \cdot z \cdot \left(2 - n + \gamma \cdot (1-n)\right)^2 - a \cdot e\right)}{\left(8 \cdot z \cdot \left(2 - n + \gamma \cdot (1-n)\right)^2 - e^2\right)^2} \right) - \left(\frac{3 \cdot z \cdot (a-e)(18 \cdot z - a \cdot e)}{\left(18 \cdot z - e^2\right)^2} \right)$$

Values of $\Delta P^{N,S} \geq 0$ indicate that network industries are more polluting than standard ones, while for values of $\Delta P^{N,S} < 0$ the reverse holds true. The threshold value of the network externality, $n^{TT}(a,e,\gamma)$, such that $\Delta P^{N,S} = 0$ is analytically complex.

As a consequence, to derive some conclusions, we run numerical simulations for precise parameter values and draw the corresponding figures (Fig. B.3). The two graphs on the top report $\Delta P^{N,S}$ for a relatively small market size ($a - e = 2$), while the two on the bottom depict $\Delta P^{N,S}$ for a relatively large market size ($a - e = 5$), in the presence of an inefficient ($z = 1$, left boxes) and efficient ($z = .25$, right boxes) abatement technology. As reported in the main text, the pictures reveal that, in the presence of an inefficient cleaning technology, the expansion of production levels due to the network externalities leads to high pollution because firms are not incentivized to abate emissions.

However, when the "green" technology is adequately efficient, in the presence of strong network effects, the indirect negative price effect due to output expansion on revenues is relevant, and firms are incentivized to invest more in cleaning technologies which now are economical. This leads both to the reduction of the firms' operative costs and to abate emissions.

As a consequence, pollution can be lower than in standard industries, provided that, as highlighted, the network effects are adequately strong.

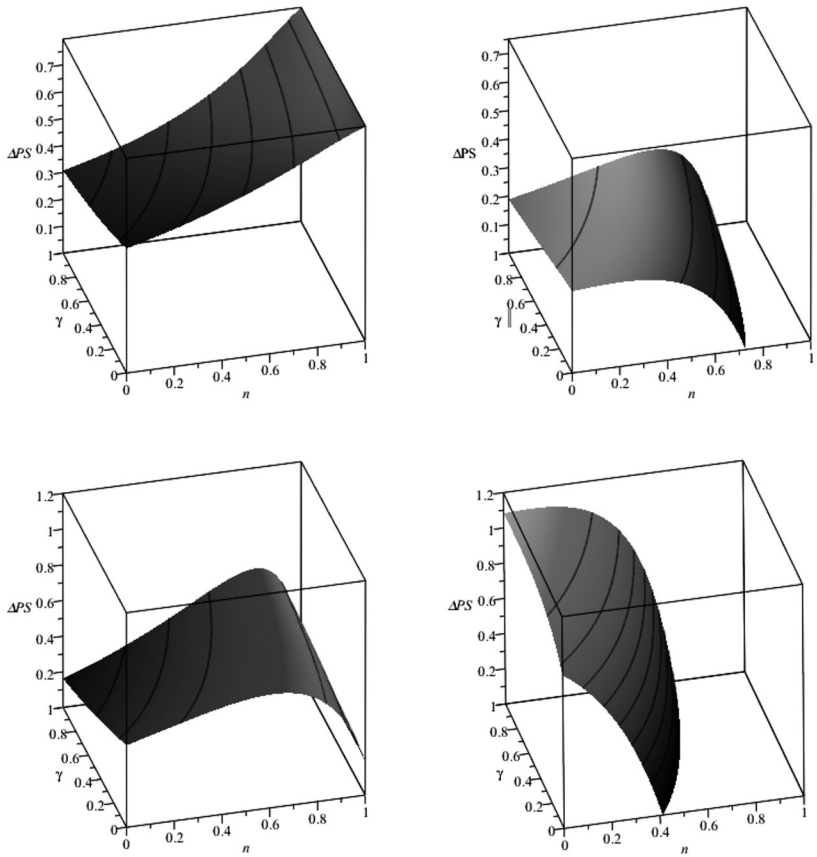

Fig. B.3: Plots of the function $\Delta P^{N,S}$ *in the* (n, γ)*–space. Parameter set:* $(a - e = 2)$ *upper boxes;* $(a - e = 5)$ *lower boxes; z=1, left boxes, z=.25 right boxes.*

B.2.2 A graphical representation of Results 4

Both parts i) and ii) of Result 4 in the main text can also follow from a simple visual inspection of the parametric regions which depict the signs of the relationship between network effect and level of pollution, comparing - as regards the part i) - Fig. B.4 A) duopoly and B) monopoly, for a set of parameters such that $\Delta ERA > 0$, and - as regards the part ii) - Fig. B.5 A) γ*=1* and B) γ*=0.05*.

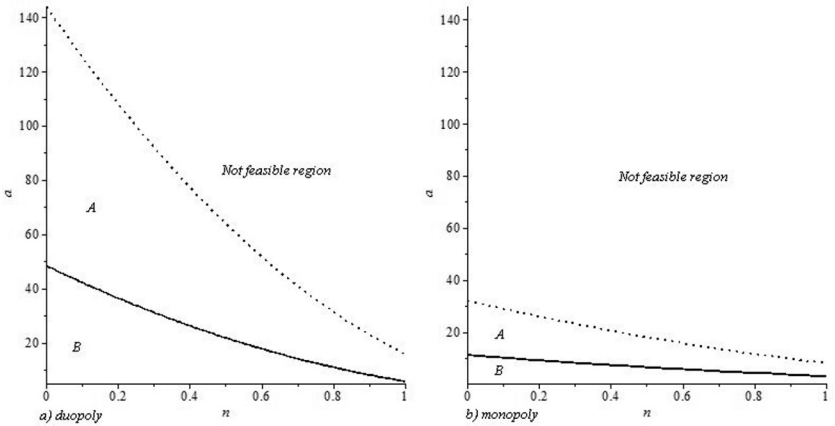

Fig. B.4: Plots of the regions with opposite effects of the network externalities on total pollution, in the plane (n,a). Parameter set: z=1, e=0.5, γ=1. The curves represent: i) a^{*D} (solid line) and $a^{\circ D}$ (dotted line) in a) duopoly; ii) a^{*} (solid line) and a° (dotted line) in b) monopoly. Legend: a) duopoly: A= region in which $\frac{\partial P^D}{\partial n} < 0$, B= region in which $\frac{\partial P^D}{\partial n} > 0$; b) monopoly: A= region in which $\frac{\partial P}{\partial n} < 0$, B= region in which $\frac{\partial P}{\partial n} > 0$.

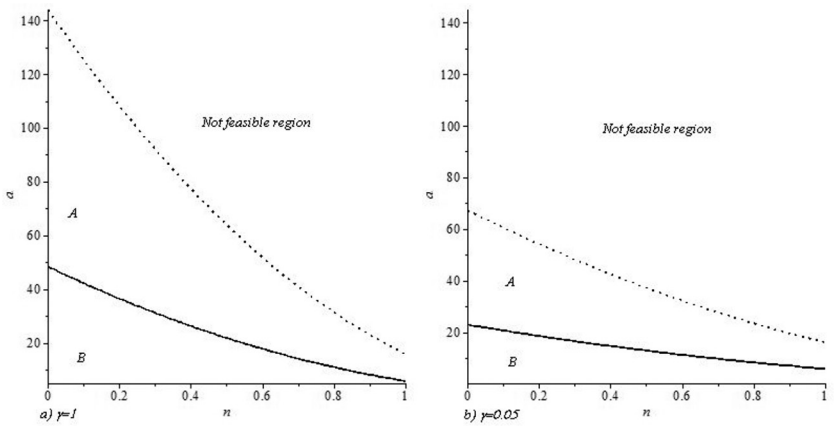

Fig. B.5: Plots under duopoly of the regions with opposite effects of the network externalities on total pollution in the plane (n,a), for products perfect substitutes (left box: a) γ=1) and strongly differentiated (right box: b) γ=0.05). Parameter set: z=1, e=0.5. The curves represent a^{*D} (solid line) and $a^{\circ D}$ (dotted line). Legend: a) γ=1: A= region in which $\frac{\partial P^D}{\partial n} < 0$, B= region in which $\frac{\partial P^D}{\partial n} > 0$; b) γ=0.05: A= region in which $\frac{\partial P}{\partial n} < 0$, B= region in which $\frac{\partial P}{\partial n} > 0$.

Indeed, Fig. B.4 neatly shows that the feasibility and, more importantly, the parametric region where the relation "more network externality-less pollution" holds are larger under duopoly when the technology is not extremely efficient. As Fig. B.5 shows, the product differentiation tends both to reduce the threshold levels of the market size and to shrink the parametric areas making them close to (but always larger than) those of the monopoly case.

B.3. General union utility function

The robustness of the results of the reference framework has been checked assuming a more general union's utility function, which attaches a different weight on the preferences over wages and employment level. Thus, the union's utility function in (3) in the main text (setting $w^{\circ} = 0$ for analytical simplicity) is modified as follows

$$V^S = (w - ek)^{\theta} q^{(1-\theta)}, \tag{B.1}$$

where the upper script stands for "sensitivity". In fact, the parameter $\theta \in [0,1]$ represents the union's wage sensitivity (or wage orientation): values of $\theta < (>)0.5$ imply that the union is less (more) concerned about wages and more (less) concerned about jobs.[13] Moreover, it is worth to note that the parameter θ could also be interpreted as a crude measure of the union's bargaining power in the case of a typical firm-union Nash bargaining over the wage, in the sense that a higher θ would approach a higher union's power in wage negotiations.[14] Indeed, both the parameter measuring the union's bargaining power and the parameter θ "will enter the Nash maximand in a mathematically similar way – and we might, in some applications, even choose the alternative interpretation of θ as reflecting the relative bargaining power of the trade union" (Lommerud and Straume, 2012, 184).

From (B.1), the maximization problem with respect to the wage level yields

$$w^S = a\theta + ek(1-\theta), \tag{B.2}$$

which shows that the optimal wage the union sets is a linear combination of the market size and the environmental damage. In particular, the more wage-oriented the union is, the less is worried about the environmental damage, and this implies

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[13] Note that, when $\theta = 0.5$, this functional form represents the same union's preferences given by (3). Moreover, the parameter θ may also indirectly represent the degree of 'insider' power, in the sense that the more important insiders into the unions are, the stronger is the union's preference for wages (all else equal) (e.g., Lommerud and Straume, 2012).

[14] In this model the introduction of a bargaining model over wages makes algebraically intractable the solutions. However, even assuming a monopoly union, one can think the parameter θ as a rough measure of the union's bargaining power.

that, in the presence of a wage-oriented union, the firm is less incentivized to reduce such a damage. Substitution of (B.2) into the output expression in (5) in the main text gives production as a function of the cleaning technology

$$q^S(k) = \frac{(1-\theta)(a-ek)}{2-n}. \tag{B.3}$$

Substituting (B.2) and (B.3) into the monopolist profit function, subsequent maximisation with respect to the level of the cleaning technology leads to the optimal emission intensity

$$k^S = \frac{z(2-n)^2 - ae(1-\theta)^2}{z(2-n)^2 - e^2(1-\theta)^2} \tag{B.4}$$

Substituting (B.4) backwards, the final equilibrium output is

$$q^S = \frac{z(1-\theta)(2-n)(a-e)}{z(2-n)^2 - e^2(1-\theta)^2} \tag{B.5}$$

Analytical inspection of (B.4) and (B.5) reveals that

$$\begin{aligned} &1)\ k^S > 0 \Leftrightarrow a < a^{0S} = \frac{z(2-n)^2}{e(1-\theta)^2} \\ &2)\ q^S > 0, \pi^S > 0 \Leftrightarrow e^2 < \frac{2(2-n)^2}{(1-\theta)^2}, e < a < a^{0S}, \end{aligned} \tag{B.6}$$

from which it can be easily derived that the higher is the union's wage orientation, the larger is the feasible market size. Therefore, the wage sensitiveness represents a force that works in an opposite direction with respect to the network effects, in the sense that it tends to expand both the threshold values of the size of the market and the union's environmental interest for which the economy is feasible. A further investigation leads to the following Lemma:

Lemma B.1. i) $\frac{\partial k^S}{\partial \theta} > 0, \frac{\partial q^S}{\partial \theta} < 0$; ii) $\frac{\partial k^S}{\partial n} < 0$, $\frac{\partial q^S}{\partial n} > 0$ iii) $\frac{\partial^2 k^S}{\partial n \partial \theta} > 0, \frac{\partial^2 q^S}{\partial n \partial \theta} < 0.$

The content of the part i) of Lemma B.1 is expected: in fact, the higher the wage orientation, the higher the firm's costs and, therefore, 1) the lower the selected level of the abatement technology to reduce the fixed costs, 2) the lower the production. Also, the part ii) is expected (because the union's preference does not change the role of the network effect already evidenced by Lemma 1 in the main text). The part iii) says that, since the wage-oriented union is less interested to the environmental damage, then also the pressure of the network

effect for reducing such a damage result to be weakened; moreover, since the wage-oriented union lowers output then also the output-increasing role of the network effect is weakened (as a simple visual inspection of (B.3) reveals). In other words, a wage-oriented union tends to dampen both the opposite effects of the network intensity highlighted in the previous section (e.g., Lemma 1 in the main text), so that the net effect caused by the wage-aggressiveness on total pollution remains a priori ambiguous. However, the analytical investigation of the relationship between pollution and network reveals a clear-cut effect of the union's wage-orientation on the same, as below shown.

With regard to total emissions, using (B.4) and (B.5) it is obtained that

$$P^S = k^S q^S = \frac{z(2-n)(1-\theta)(a-e)\left[z(2-n)^2 - ae(1-\theta)^2\right]}{\left[z(2-n)^2 - e^2(1-\theta)^2\right]^2} \tag{B.7}$$

It is easy to show that if the network effect is absent (i.e. $n = 0$), then the higher the union's wage-orientation is, the lower the pollution level is: this means that the reducing effect of higher wages on quantities overweighs that on the emissions abatement. However, when an increasing network effect is present, the things may change, as below shown:

$$\frac{\partial P^S}{\partial n} \underset{<}{\overset{>}{}} 0 \Leftrightarrow a \underset{>}{\overset{<}{}} a^{*S} = \frac{z(2-n)^2\left[z(2-n)^2 + 3e^2(1-\theta)^2\right]}{e(1-\theta)^2\left[3z(2-n)^2 + e^2(1-\theta)^2\right]},$$

with $a^{*S} < a^{0S}$, from which it follows that the higher the union's wage orientation is, the less likely is the occurrence of the pollution-reducing effect, i.e. $\frac{\partial a^{*S}}{\partial \theta} > 0$.

The intuition behind the latter result is as follows. On the one hand, a higher wage orientation moderates the union's perceived damage from pollution and lowers the choice of the abatement technology level, which tends to increase emissions; on the other hand, it decreases employment and output which, in turn, reduces emissions. Moreover, the union's wage-orientation weakens the established positive effects of network on emissions and on emissions abatement; however, it remains to establish which of the two effects is more weakened to reveal whether and how such a wage-orientation affects the relationship between pollution and network. In fact, as displayed in Fig. B.6 below (drawn for a fixed levels of *z=1*), while in the absence of network effects the reducing effect of higher wages on quantities overweighs that on the emissions abatement, when the network effect is introduced and is increasing, the emissions abatement may be reduced more than the emissions, as the part iii) of Lemma B.1 suggests, and as is clearly illustrated in Fig. B.6 below, where (for example with *a=6* and *e=0.5*) with a more wage-oriented union total pollution is lower when *n=0* but

becomes higher when n is beyond about *0.6*. The role played by the union's preferences on total pollution crucially depends on the intensity of the network effect, as summarized in the next remark.

Remark. When the network effect is not intense, the total pollution is lower if the union is wage aggressive; on the other hand, if the network effect is adequately intense, then the total pollution is lower if the union is employment oriented (see Figure B.6 below).

If the goal is to reduce total pollution, then the policy implication is that in sectors with strong network externalities the presence of a union employment oriented should be preferred, while in sectors with low network effects is preferable a wage oriented union.

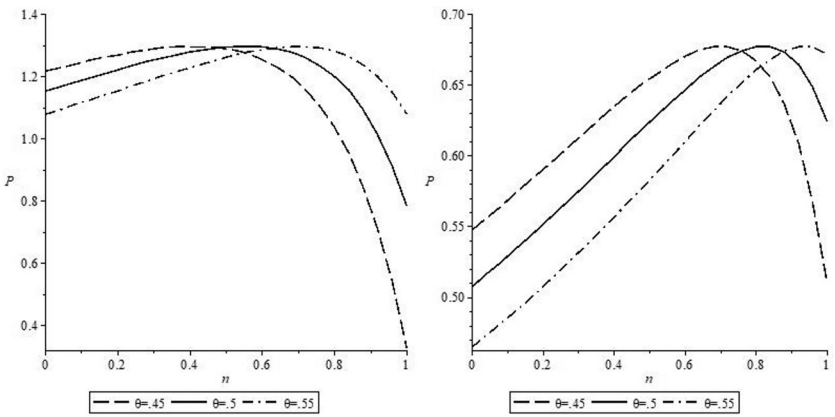

Fig. B.6. Total pollution, P^S, when the network effect (n) increases for three values of the wage orientation parameter (θ)*, far a given technology level* ($z = 1$)*. Left box: a=6, e=0.5; Right box: a=3, e=0.8.*

For example, in Fig. B.6, left box, if $n = 0.1$ the total pollution is $P = 1.14$ when the union is relative wage oriented, and $P = 1.23$ when the union is relative employment oriented: on the other hand, if $n = 0.8$, the total pollution is $P = 1$ if the union is employment oriented, and $P = 1.27$ if the union is wage oriented.

To sum up, the presence of network may still increase or reduce pollution, confirming the result of the previous section, but the higher the union's wage-orientation is, the less likely the network effect tends to reduce pollution.

B.4. Government's choice of the "environmental standard"

The model has been also extended to the case in which, rather than the firms, it is the Government that selects the abatement level (the "environmental standard") firms have to adopt in order to maximize the social welfare. In this case,

making use of (5) and (6) in the main text, it is obtained that the union utility, the profits and the consumer surplus (defined as $CS = \frac{(1-n)q^2}{2}$) are, respectively

$$V = \frac{(a-ek)^2}{4(2-n)},\ \pi = \frac{(a-ek)^2}{4(2-n)^2} - z(1-k)^2,\ CS = \frac{(1-n)(a-ek)^2}{8(2-n)^2}.$$

As a consequence, the social welfare is given by $SW = V + \pi + CS$. Maximization of social welfare with respect to k leads to

$$k^G = \frac{7ae + 32z + 8n^2z - (3ae - 32z)n}{7e^2 + 32z - 8n^2z + (3e^2 - 32z)n} \tag{B.8}$$

where the upper script G stands for "Government". The positivity condition for (B.8) is ensured by the following inequalities:

$$\begin{aligned} &1)\ e^2 < \frac{4z(14-6n)(2-n)^2}{(7-3n)^2} \\ &2)\ k^G > 0 \Leftrightarrow a < a^{0G} = \frac{8z(2-n)^2}{e(7-3n)}. \end{aligned} \tag{B.9}$$

A straight forward observation of a^{0G} and a^0 in (10) in the main text (see condition 1) reveals that, if the Government fixes the socially optimal cleaning technology, the market size feasibility is smaller than in the case in which the firm selects the level of cleaning technology to adopt, i.e. $a^{0G} < a^0$. Substitution of (B.8) into the expression for quantity leads to

$$q^G = \frac{4z(2-n)(a-e)}{8n^2z + (3e^2 - 32z)n - 7e^2 + 32z} \tag{B.10}$$

Having assumed that $a > e$, and recalling (B.9), also the positivity of quantity is ensured. Then, it is natural to compare the levels of polluting production and pollution abatement in the two cases of the choice of the cleaning technology by Government and by firm. First, a direct comparison of k and k^G shows that $k > k^G$: the Government chooses a higher level of the abatement technology with respect to the firm. Second, a direct comparison of q and q^G shows that $q < q^G$: the output is higher when the Government chooses the abatement technology, because firms may produce more being higher the investment in cleaning technology.

The rationale for these comparative results is that the Government, on the one hand, reduces the emissions more than the firm because it is careful of the workers' utility (while the firm is careful only of the pollution damaging workers to the extent that the consequent higher wages damage own profits);

however, on the other hand, it increases production because - considering the overall social welfare - has to take into account also the welfare of consumers that are not directly affected by pollution and can be interested in adequately large levels of output that lead to a lower market price.

Now, it is natural to ask for the role played by the network effect on the pollution when the cleaning technology is chosen by the Government and compare it with that of the case of cleaning technology chosen by firm. Therefore, the following holds:

Lemma B.2: i) $\frac{\partial k^G}{\partial n} < 0$ and $\frac{\partial q^G}{\partial n} > 0$; ii) $\left|\frac{\partial k^G}{\partial n}\right| > \left|\frac{\partial k}{\partial n}\right|$ and $\frac{\partial (q^G - q)}{\partial n} < 0$.

Hence, as expected, the network effect still favours both the pollution abatement and polluting production; however, the former effect is more intense under the Government's cleaning decision, while the latter tends to become similar between the two cases when the network effect becomes more intense.

In other words, for an increasing network effect the abatement becomes larger under the Government's cleaning decision while the polluting output becomes very similar regardless of whether the cleaning decider is the Government or the firm. As a consequence, in the overall, we expect that the pollution-reducing effect of the network intensity is more likely under the Government's cleaning decision.

The total pollution level is the following:

$$\text{(B.11)} \qquad P^G = k^G q^G = \frac{4z(2-n)(a-e)[8n^2z + (3ae - 32z)n - 7ae + 32z]}{[8n^2z + (3e^2 - 32z)n - 7e^2 + 32z]^2} .$$

Therefore, from (B.11), it is obtained that

$$\frac{\partial P^G}{\partial n} \gtrless 0 \Leftrightarrow a \lessgtr a^{*G} = \frac{8z(2-n)^2(3e^2n - 8n^2z - 9e^2 + 32nz - 32z)}{e(48n^3z + 3e^2n - 312n^2z - 7e^2 + 672nz - 480z)} .$$

It is straightforward to demonstrate that $a^{*G} < a^{0G}$, showing that the pollution-reducing effect of an increasing network intensity is more likely under the Government's cleaning decision, as above discussed.

Remark. As expected, the total pollution is lower if the Government establishes the "environmental standard". However, it is worth to note that, in the presence of network effects, the total pollution is significantly reduced with respect to the case in which the firm decides the level of emission's abatement (see Fig. B.7 below).

The policy implication is that, in sectors with strong network externalities, if the Government selects the abatement level (the "environmental standard"), the pollution reduction effect due to the network intensity is decisively more pronounced than in the case the firm chooses it. For example, looking at Fig. B.7, with standard goods (i.e. $n = 0$), the total pollution is $P^G = 0.9$ (Government) and $P = 1.29$ (firm). However, when $n = 0.9$, $P^G = 0.58$ and $P = 1.64$. Therefore, if the objective is to reduce the pollution, the Government's introduction of an "environmental standard" is rather successful.

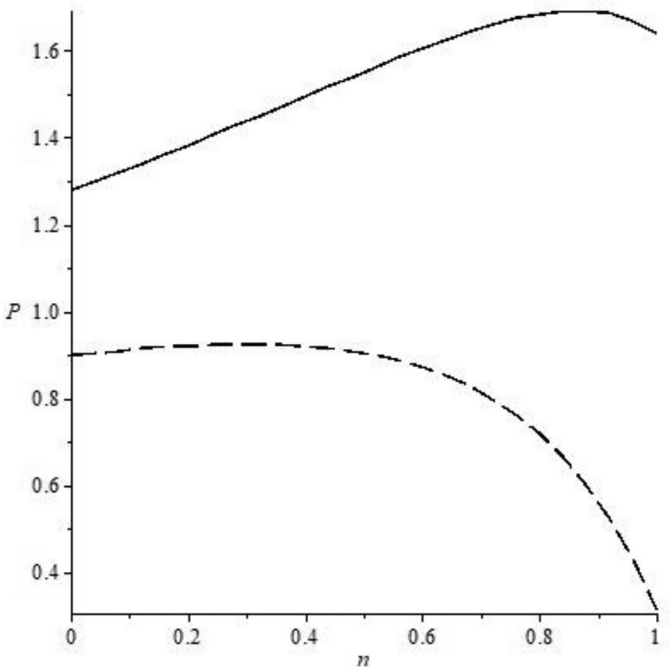

Fig. B.7. Levels of total pollution, P^G and P, when the network effect (n) increases, for given a=6, e=0.3, z=1. Legend: solid line, technology level chosen by the firm; dashed line, technology level chosen by the Government.

Fig. B.7 shows the key (quantitative) difference between the models in which the Government selects the level of the technology adoption and that in which the firm chooses that level.

Summarizing, the qualitative results obtained in the reference framework in the main text are also confirmed under this model's specification.

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Relationship between country risk volatility and indices based on unstructured information*

Relación entre volatilidad del riesgo país e índices basados en información no estructurada

Martín Llada**

Abstract

This work assesses whether certain indicators constructed from unstructured information published in newspapers contain useful information regarding dynamics of Argentina's country risk volatility, estimated from a GARCH(1,1) model. The analysis covers the period 1998-2019. One standard deviation increment in the indicator that captures manifestations of pessimism is followed by an increment of approximately 0.2% in expected country risk volatility in the consecutive quarter. Out-of-sample exercises confirm that these non-traditional indicators allow for gains in forecast accuracy. These findings are robust to changes in the set of predictors, the specification of the model and the incorporation of new media content.

Key words: *Macroeconomic forecasting, natural language processing, uncertainty, country risk volatility.*

JEL Classification: *E47, E70, G17.*

Resumen

Este trabajo evalúa si ciertos indicadores construidos a partir de información no estructural publicada en los periódicos contienen información útil respecto de la dinámica de la volatilidad del riesgo país de Argentina, la que es estimada

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** Universidad de Buenos Aires. Facultad de Ciencias Económicas. Buenos Aires, Argentina. CONICET-Universidad de Buenos Aires. Instituto Interdisciplinario de Economía Política de Buenos Aires. Buenos Aires, Argentina. E-mail: lladamartin@gmail.com

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a partir de un modelo GARCH(1,1). El análisis cubre el periodo 1998-2019. Se evidencia que un incremento de una desviación estándar en el indicador que captura manifestación de pesimismo anticipa, en promedio, un aumento de 0,2% en la volatilidad del riesgo país durante el trimestre subsiguiente. Un conjunto de ejercicios de pronóstico fuera de la muestra evidencia que los indicadores no tradicionales permiten mejorar la precisión del pronóstico. Estos resultados son robustos a cambios en el conjunto de regresores, la especificación del modelo y la incorporación de nuevos contenidos difundidos en la prensa.

Palabras clave: *Pronósticos macroeconómicos, procesamiento del lenguaje natural, incertidumbre, volatilidad del riesgo país.*

Claificación JEL: *E47, E70, G17.*

1. Introduction

The perception of investors associated with the ability of a given country to honor its external commitments is captured by the sovereign risk premium. The pessimistic perception associated with these phenomena is reflected in increases in country risk. In this sense, the level of uncertainty about this variable is especially relevant for policymakers, taking into account its potential impacts over the business cycle. Fernández-Villaverde *et al.* (2011) and de Ferra and Mallucci (2020) show how changes in the volatility of the real interest rate at which emerging economies borrow have an effect on real economic variables (e.g., output, consumption, investment, hours worked, etc).

The level of uncertainty is a non-observable concept, which could be approximated using unstructured information (Baker *et al.*, 2016, Ghirelli *et al.*, 2019, Aromi, 2020). Can valuable indicators of uncertainty about the country risk variable be built using natural language processing tools? Can these indicators based on unstructured data provide information on the dynamics of the country risk volatility? Is the information provided by media content different from the information provided by traditional indicators? In this work we implement an empirical analysis to generate a proxy for the perception of uncertainty about the country risk variable. More specifically, economic press content is processed to generate a set of indicators that approximate different manifestations linked to uncertainty, pessimism, and fear in a specific topic[1]: country risk.

There is a wide set of studies that have focused on studying the determinants of the country spreads (Edwards 1985, Kieguel and Lopetegui, 1997, Nogués and Grandes, 2001, Rowland, 2004, Uribe and Yue, 2006, Azar *et al.*, 2007, Grandes, 2007, González-Rosada and Levi Yeyati, 2008, Bellas *et al.*, 2010,

[1] These subjective states are identified by inspecting literature and by recurrence to subjective judgment. The non-traditional indicators aim to capture an expectation of negative scenarios.

Csonto and Ivasckenko, 2013, Mpapalika and Malikane, 2019). In general, these studies conclude that the sovereign risk is influenced by changes in variables related to macroeconomic aggregates, intertemporal liquidity, contagion effects and external shocks. However, there have been very few papers that focus on understanding the dynamics of country risk volatility (Fernández-Villaverde *et al.*, 2011, Palic *et al.*, 2017, de Ferra and Mallucci, 2020). In this sense, this work aims to shed light on this variable of interest, given its key importance in public debt and macroeconomic uncertainty.

This paper focuses on the behavior of the country risk volatility of Argentina, whose evolution is major considering its impact on the real interest rate at which this country borrows. Additionally, this work is timely taking into account that Argentina returns to international capital markets in 2001, following a long period of exclusion. In this sense, we approximated the sovereign risk by the EMBI spread (Emerging Market Bond Index spread) computed and reported by J.P. Morgan from the United States. The analysis covers the period 1998-2019. The volatility is approximated by the conditional standard deviation of the difference in logarithms of the sovereign risk estimated from a GARCH(1,1) model. In turn, the indicators based on unstructured information are built from a large collection of text from La Nación, a prominent Argentine newspaper.

Every day, structured and unstructured information is available and potentially relevant to be used by agents of the economy to formulate expectations and make decisions, which influence the dynamics of real economic and financial variables. The literature has focused on studying the information captured by traditional economic indicators; however, there is a growing body of studies that shows the usefulness of exploiting unstructured information in the field of economics (for example, Tetlock, 2007, García, 2013, Loughran and McDonald, 2011, Baker *et al.*, 2016, Ghirelli *et al.*, 2019, Aromi, 2020, among others). In this sense, to exploit these sources of unstructured information, non-traditional indicators based on information published in the economics section of the newspaper La Nación are developed. To this aim, first, an unsupervised machine-learning model called Dirichlet Latent Allocation (LDA) was trained to identify all those articles associated with the country risk topic. Finally, following Aromi (2020), quantitative indicators were computed in order to approximate different manifestations of subjective states associated with this topic, using lists of words that belong to the same semantic space that arise from training an unsupervised machine learning model of words vector representation (Pennington *et al.*, 2014).

Preliminary evaluations show that certain non-traditional indicators based on the unstructured information on the country risk topic published by the media are able to explain the future levels of the country risk volatility of Argentina. More specifically, an unexpected increase in pessimism generates a significant increase in the country risk volatility of Argentina. The initial increase amounts to about 0.17 standard deviations in the second quarter, and gradually fades away. These results are robust to changes in the way the country risk volatility is modeled and also the model specification.

Additionally, this work studies to what extent the set of non-traditional economic indicators proposed have relevant information regarding the dynamics of the country risk volatility of Argentina. In this sense, first, an in-sample forecast exercise is carried out from which it is evaluated whether the set of proposed predictors provides useful information on the future values of country risk volatility. Based on these exercises, the results confirm that non-traditional indicators have valuable information regarding the future evolution of country risk volatility. In particular, estimated forecasting models indicate that a one standard deviation increment in the indicator that captures manifestations of pessimism is associated to an increment of 0.21 standard deviations in the next quarter expected country risk volatility of Argentina. Second, out-of-sample forecasts exercises confirm that indicators that exploit unstructured information allows for significant gains in forecast accuracy of country risk volatility computed for Argentina. In this sense, the positive results provide evidence on the usefulness of the proposed indicators to explain the future evolution of the interest variable.

In order to strengthen the patterns documented in this work, we perform a series of robustness exercises. First, the in-sample forecast model is estimated in order to evaluate if the observed regularities still stand when the volatility of the country risk is approximated from an alternative methodology. Second, a set of traditional economic indicators that approximate the internal and external position of the country are incorporated into the forecasting models. Third, dummies variables are incorporated in the forecast model in order to evaluate whether the effects of non-traditional indicators intensify during periods of high volatility. Fourth, new content published by other media are incorporated, namely: Página 12 and Ámbito Financiero. In all cases, the finding previously mentioned is consistent with the robustness exercises. In sense, the results remain unaltered by changes in the model specification, the incorporation of new regressors and new unstructured content. Also, the statistical exercise would seem to suggest that the information provided by the proposed non-traditional indicators based on unstructured information is different from that provided by traditional macroeconomic indicators. Finally, the in-sample forecast model is used to assess whether the regularities reported for Argentina are present in other emerging countries: Brazil, Chile and Peru. The results suggest that non-traditional indicators have useful information regarding the future levels of country risk volatility for the case of Brazil, while they do not seem to capture valuable information beyond what the autoregressive model communicates for Chile and Peru.

The findings show that empirical studies that focus on subjective states[2] can contribute to improving our understanding of economic dynamics. This result emerges once it is recognized that economic processes emerge as a result of the coevolution of structural and subjective elements. Taking this perspective

[2] We understand subjective states as perceptions, beliefs or opinions about a specific topic.

into account, it is necessary to find sources of information that allow estimating elements associated with subjective states that can provide new knowledge.

This work contributes to three main strands of the literature. First, this document is aligned with a literature that aims to model the volatility of the risk premium and study its association with the business cycle. Fernández-Villaverde *et al.* (2011) show that the movements in the country-spread volatility, following a likelihood-based approach, faced by four emerging economies (Argentina, Brazil, Ecuador and Venezuela) are negatively correlated with a set of real variables such as the output, consumption and investment. Furthermore, they find that periods of high sovereign spreads are associated with periods of high volatility. de Ferra and Mallucci (2020) estimate the volatility of the risk premium for Argentina following the work of Fernández-Villaverde *et al.* (2011). The authors show times of high interest rate spread volatility are associated with high spreads, low consumption, low output, and a positive trade balance. The current study contributes to this strand of research from a simple model that manages to capture in a favorable way the dynamics of the country risk volatility of Argentina.

Second, this work contributes to a growing set of contributions that use unstructured information to describe dynamics in macroeconomic and financial settings. For example, there are studies that show that measures of optimism or pessimism based on newspaper content predict the stock markets returns (for example, Tetlock, 2007, García, 2013, Loughran and McDonald, 2011). Baker *et al.* (2016) propose an index that measures economic policy uncertainty (the so-called Economic Policy Uncertainty - EPU) computing the fraction of news articles that make a reference to uncertainty and to economic policy. The authors show that this index is closely related to macroeconomic events and is shown to anticipate macroeconomic trajectories in VAR estimations. Ghirelli *et al.* (2019), provide a new EPU index for Spain, based on the methodology of Baker *et al.* (2016). They show that an uncertainty shock yields a significant negative response of real economic variables (e.g., GDP, private consumption and private investment). On the other hand, Baker *et al.* (2019) propose an indicator of volatility in the stock market based on news published in the press for the US, which shows a strong association with the indicator of volatility in the stock market: VIX (Chicago Board Options Exchange Volatility Index) and the realized volatility on the S&P 500. In turn, Aromi (2020) shows that quantitative indicators associated with different subjective states on unstructured press information provide valuable information on future dynamics of US economic activity. Although the current study uses different methodology and sources of unstructured information with respect to the works mentioned previously, the spirit of the statistical exercises is similar. In this sense, the present work contributes to this growing literature based on a set of exercises that show the usefulness of incorporating indicators built from information published by the press into economic models. In particular, this work shows that certain non-traditional indicators contain valuable information that explains the future evolution of the country risk volatility of Argentina. Additionally, a novel contribution of this

work is related to the construction of non-traditional indicators, which is made on a set of specific topics, identified through the LDA model. We believe that this contribution helps to improve the accuracy of the indicators.

Third, our work contributes to a literature that has proven the usefulness of non-traditional data sources (so-called big data) in order to provide valuable information in low-income developing countries. In this sense, Futoshi & Yin (2018) find that online search frequencies about a country, using Google Trends' data for a wide sample of developing countries, significantly correlate with macroeconomic variables, conditional on other covariates. In turn, nighttime lights extracted from processed satellite imagery have been used in economic contexts (Elvidge *et al.*, 1997, Henderson *et al.*, 2009 and Zhao *et al.*, 2020). Analogously, the current work develops indicators based on unstructured press information and evaluates its usefulness in macroeconomics contexts. These new sources of data could be used to reduce the missing data and the long-time lags in data release and improve real-time assessment of economic conditions and the ability to set sound policies.

After this introduction, the next section describes the methodology. Section 3 details the variables and the data sources used. Next, section 4 discusses the results of contemporary associations, while section 5 develops forecasting exercises. Then, in section 6 the results derived from the different robustness exercises are presented. Finally, section 7 summarizes the conclusions.

2. Methodology

A large quantity of economic data (structured and unstructured) is generated and disseminated everyday through multiple channels that individuals can use to make their economic decisions. Empirical studies usually evaluate the relationship between economic fundamentals and country risk. In this work, we incorporate a novel attribute that attempts to capture different subjective manifestations in the newspaper news in order to evaluate its ability to explain the future evolution of the country risk volatility. Therefore, in this section, we present the methodology associated with the construction of these indicators. In this sense, first, we apply a topic model in order to identify those articles that are associated with the country risk topic. Second, we build a set of quantitative indicators using lists of words that arise from applying an algorithm called GloVe. Lastly, the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model is presented to estimate the volatility of the country risk that Argentina faces.

2.1. Topic model

As previously mentioned, in this work we implement the Latent Dirichlet Allocation (LDA) model, first introduced by Blei *et al.* (2003). This model allows to automatically discover the pattern of latent topics or themes within a corpus

(that is, a collection of unstructured documents), and assign the documents to those topics and exploit these documents for a specific purpose. Therefore, this model is a statistical tool within the field of machine learning, which allows the processing of large volumes of unstructured data in order to organize, understand and summarize the information they contain. In contrast to Baker *et al.* (2016) and Ghirelli *et al.* (2019), through the LDA model, we must not define an ad-hoc list of keywords, predefined dictionaries or subjective judgments to identify the articles associated with our topic of interest.

Given a collection of documents, LDA discovers not only the topics that each document addresses, but also the prevalence of these topics in each document. The only arbitrary decision that the researcher must make is to choose the number of topics to be extracted. The objective of LDA is to infer the latent topic structure, which is performed by using the information provided by the words of the documents since they are the only observable variable. In this sense, LDA assumes that documents are random probability distributions over topics, and that topics are random probability distributions over words. In other words, each document contains a set of topics with different probabilities, and the topics contain words with different probabilities. Finally, LDA assumes the independence of words by ignoring the order in which they appear in a document (bag-of-words assumption) since this model exploits the prevalence of words.[3]

The LDA model assumes that the observed documents were generated through a probabilistic generative process. Therefore, the key inferential task of LDA is estimating the latent parameter structure of this generative process. LDA performs this task by using the words of each document to estimate the parameters of the generative process that are most likely to have generated the collection of documents observed. More precisely, LDA model assumes that a document is composed of topics subject to Dirichlet distribution, θ_d whose parameter is α, which describes the prior knowledge about how topics are distributed in documents.[4] Each topic is composed of words subject to Dirichlet distribution, φ_k, whose parameters is β, which describes the prior knowledge about how the words are distributed in each topic.[5] Then, each word (ω_n), that belong to the vocabulary N, in each document is randomly assigned to a topic. Finally, a topic is reassigned to the word given the topic assignments (Z_n), the prevalence of each topic in the document (φ) and the prevalence of the word in each topic (θ). More details can be found in Appendix A.

As we mentioned previously, the key inferential task of LDA consist in estimating the latent structure (the distribution of the parameters θ, Z and φ)[6]

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3 More details can be found in Blei *et al.* (2003) and Blei (2012).

4 A high alpha means that each document is likely to contain a mixture of most of the topics, while a low alpha value means that each document is likely to contain fewer topics.

5 A high beta value means that each topic is likely to be made up of most of the words in the corpus, while a low beta indicates that each topic will have fewer words.

6 Where Z represents the per-word topic assignments, θ represents the proportion of topics per-document (that is, the topic distribution of each document), which indicates the extent

that are most likely to have generated the observed document. In this sense, the conditional distribution of the topic structure must be calculated given the collection of documents and the Dirichlet priors. Therefore, the objective of LDA consists in computing the posterior conditional distribution of the latent variables[7] given the observed variables (the documents and the parameters of the Dirichlet distribution):

$$p\ (\theta, Z,\ \varphi |\ \omega,\ \alpha, \beta) = \frac{p\ (\theta, Z,\ \varphi\ |\ \alpha, \beta)}{p\ (\omega\ |\ \alpha, \beta)}$$

The numerator is the joint distribution of the random variables, which can be easily calculated. The denominator is the marginal probability of the observations. However, the posterior distribution cannot be computed, because the evaluation of the denominator is intractable to compute, since the distributions of the hidden variables requires marginalizing over the hidden variables to obtain the model's probability for a given corpus w and priors β and α. In order to approximate this posterior distribution, we use a Collapsed Gibbs sampling as our inference technique, a commonly used alternative introduced by Griffith and Steyvers (2004), to estimate φ, θ and Z, the latent parameters.

2.1.1. LDA implementation

The flow diagram to estimate the LDA model is summarized in Figure 1. First, a set of standard practices in the field of natural language processing is performed (Text Pre-processing Module). In this sense, a tokenization of the articles is performed (a task that is associated with breaking the text into individual words). Then we remove all punctuation, numbers, and stops words (terms such as articles, prepositions, pronouns and other words that do not have a relevant semantic value on the definition of the topics). Once the cleaning tasks are carried out, we perform a vocabulary reduction. In this sense, we only concentrate on those words that occur at least 30 times in order to reduce the word vector space.

The LDA Model Module in Figure 1 summarizes this approach described above. As previously indicated, this work uses the Collapsed Gibbs Sampling proposed by Griffiths and Steyvers (2004) to carry out the iterative process of topic inference. This approach requires to define the specification of values for the parameters of the prior distributions: α (parameter of the per-document topic distributions) and β (parameter the per-topic term distributions), which are defined in 50 / k (where k is the number of topics) and 0.1, respectively. The

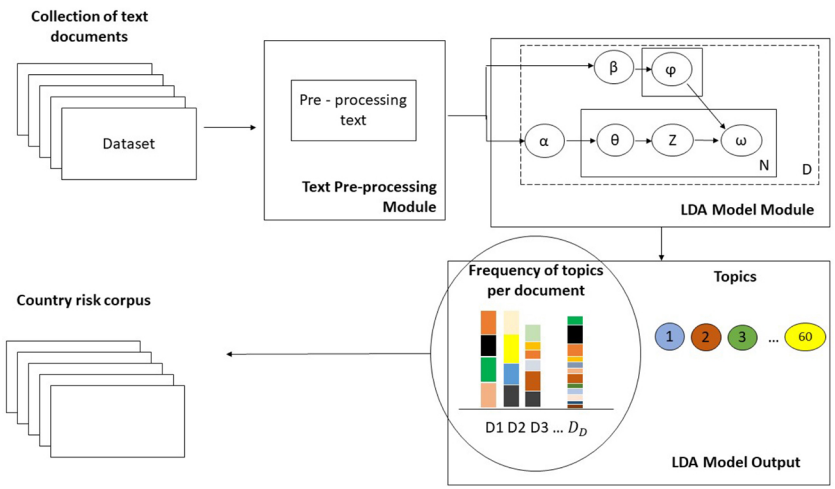
to which each document belongs to each topic, and φ represents the distribution of words in topic k, which is used to define the semantic content of each topic.

7 In the context of LDA, θ, Z, φ are hidden or latent variables.

number of topics is set at 60.[8] On the other hand, the parameter that defines the proportion of topic that the document displays (θ)[9] is used to select those articles whose proportion parameter associated with the country risk topic is maximum.

The LDA model is applied to the economics section of the newspaper La Nación (the Collection of text documents in Figure 1) in order to identify those articles that address the country risk topic. The LDA model was trained with all the articles covering the period 1996-2004 in order to avoid overfitting the model. The topics associated with country risk selected are topic 7 (whose 10 words associated with it with the highest relative probability are: fmi, fondo, argentina, acuerdo, internacional, monetario, organismo, programa, washington y banco) and topic 47 (deuda, bonos, acreedores, argentina, gobierno, canje, reestructuracion, default, títulos, oferta).[10]

FIGURE 1
STRUCTURAL OVERVIEW OF THE LDA IMPLEMENTATION



2.2. Indexes based on unstructured information

Once the corpus of documents associated with the topic of interest has been built, we proceed to compute the quantitative indexes based on unstructured

8 An analysis with different topics values was carried out, which allows us to arrive at a conclusive distribution of topics by setting k = 60.

9 θ represents the proportion of topics per-document (that is, the topic distribution of each document).

10 In English, topic 1: imf, fund, argentina, agreement, international, monetary, agency, program, washington and bank, while topic 7: debt, bonds, creditors, argentina, government, exchange, restructuring, default, securities, offer.

information published in the press. In this section we present the methodology followed in order to compute the non-traditional indices.

2.2.1. Word vector representation

In this work, word vectors models are used to learn word meaning structures. In particular, the GloVe (Global Vectors) model proposed by Pennington *et al.* (2014) is used, which produces linear structures of meaning. This model represents words as vectors and captures the global statistics of the corpus. The objective is to generate quantitative representations that summarize word semantic content by using the global statistics of the corpus and the trained vectors. In other words, this model allows us to identify relationships between words by computing the distance between their numeric representations, through simple algebraic operations. This unsupervised machine learning technique allows us to generate quantitative indicators that summarize information from the press. Furthermore, as Aromi (2020) suggests, the GloVe model has good results in tasks such as: i) resolution of ambiguity in the meaning of a word, ii) entity identification through vector composition, and iii) identification of words indicative of tone or topic. Finally, in contrast to Baker *et al.* (2016) and Ghirelli *et al.* (2019), through GloVe model, we must not define an ad-hoc list of keywords, predefined dictionaries or subjective judgments to identify relevant words in the press related to negative scenarios.

Through the GloVe model, several indices designed to capture manifestations of different subjective states in an economic context can be computed. For this task, first, word vectors are trained using a corpus through which a structure of meaning is built. In other words, for each word, a vector of numbers is obtained, which represents its meaning. Second, a keyword or set of words is chosen that expresses the subjective state that is to be represented. Then, the words strongly associated with the key term defined in the second step are identified, through computing the distance between their respective representative vectors. Finally, the quantitative indicator is given by the frequency of these words (the key term and the list of words strongly associated with it) appear in the corpus. The ability of word vectors to capture the meaning of a word depends on how informative the training corpus is and the effectiveness of the learning model.

The GloVe model trains word vectors in order to capture information about the co-occurrence of words in the training corpus, that is, information on the number of times a word appears in the context of other words. This method is global in the sense that all vectors are computed through an individual optimization exercise. Let W be the size of the vocabulary[11] and let X_{ij} denote the number of times word i occurs in the context of (i.e., is close to) word j. The loss function of the GloVe model is given by:

[11] The vocabulary size will be discussed later.

$$\sum_{i,j=1}^{W} f\left(x_{ij}\right)\left[v_i^T * \tilde{v}_j + b_i + \tilde{b}_j - \log(x_{ij})\right]^2$$

where v_i and $\tilde{v}_j$ are word vectors, $f(x_{ij})$ is a concave increasing weighting function whose function is to weight the most frequent co-occurrences in order to limit the influence of frequent word co-occurrences[12]. b_i and $\tilde{b}_j$ are word biases, which are used to account for differences in the frequency of words. This is a log-bilinear regression model. In other words, the training objective of GloVe is to learn word vectors such that their dot product equals the logarithm of the words' probability of co-occurrence. The model is fitted by using stochastic gradient descent (Duchi *et al.*, 2011). More details can be found in Pennington *et al.* (2014).

Following the parameters values that are in line with those used in the natural language processing literature, the vector dimensionality is 100 and the window size used to compute the term co-occurrence is 5. The vocabulary used in the implementation is given by words with a frequency of100 or higher in the training corpus. An analysis of the robustness of this implementation indicates that the results are not sensitive to variations in the values of these parameters. Vector representations of words are computed by using the package text2vec in platform R, using as a training corpus the articles of the economics section of the newspaper La Nación from 1996-2004 (as mentioned in section 2.1.1, cleaning tasks were carried out).

2.2.2. Quantitative indexes

As previously mentioned, this paper aims to analyze the information content of a set of non-traditional indicators regarding the dynamics of country risk volatility. Therefore, in this subsection, we are going to mention how to generate the quantitative indicators from unstructured information published in the press using the knowledge captured by word vectors, following several techniques of natural language processing. The flow diagram to build the quantitative indexes is summarized in Figure 2.

The procedure that generates the indicators which capture different manifestations of subjective states in the articles that address the country risk topic published by the press involves several steps, once the GloVe model was trained. First, identifying a keyword that expresses the subjective state that is to be represented in the content (e.g., ''uncertainty'').[13] Next, the set of K most closely related terms are found based on the cosine distance, a similarity measure, between the respective vectors (which arise from the GloVe model), that is, the distance between the vector associated with the keyword and all words in the

[12] More specifically, following Pennington *et al.* (2014), the weighting function $f(x) = (\frac{x}{100})^{\alpha}$, *si* $x < 100$, *otherwise* $f(x) = 1$.

[13] The keyword is defined by the user.

vocabulary W. Finally, the indicator is given by the frequency of the selected terms in the set of articles that address the country risk topic. See Figure 2.

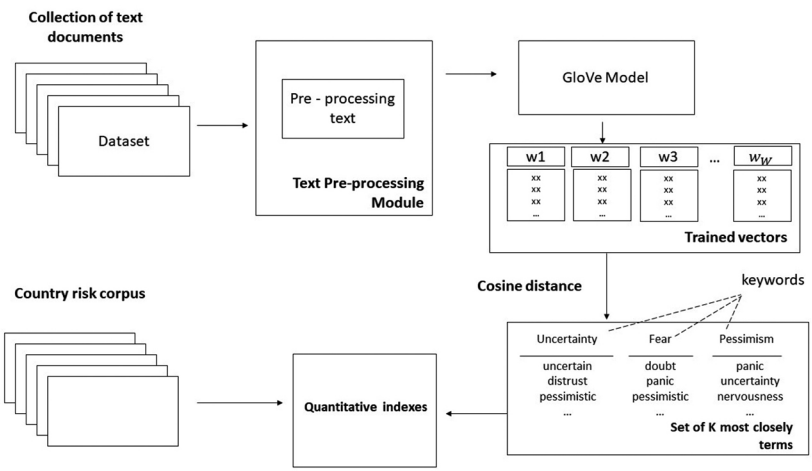
More formally, given a word $w \in K$, where K is the list of words and T is the total number of words in the selected text C. The computed index for the selected text subset is given by:

$$I_C^k = \frac{\sum_{w\ e\ K} c_w}{\sum_{w\ e\ T} c_w}$$

where c_w indicates the number of times the word w appears in the selected set of text C. The set of selected text corresponds to the articles that address the country risk topic identified through the LDA topic model (Country risk corpus in Figure 2).

Taking into account the considerable level of attention placed on the concept of uncertainty (Baker *et al.*, 2016, Jurado *et al.*, 2015; Rossi & Sekhposyan, 2015), an indicator that captures manifestations of "uncertainty" is computed and evaluated. Furthermore, indicators that approximate related but different manifestations of different subjective states are constructed. More specifically, quantitative indicators that capture manifestations of "pessimism", "fear" are proposed.

FIGURE 2
STRUCTURAL OVERVIEW OF THE QUANTITATIVE INDEXES



2.3. GARCH model

In order to obtain the country risk volatility of Argentina, a univariate generalized autoregressive conditional heteroskedasticity (GARCH) model, proposed by Bollerslev (1986), is estimated. This model allows to model the unobserved variance of series, which are characterized by large fluctuations with respect to their mean and whose variability changes over time. The basic idea of the GARCH(1,1) model is that the conditional variance has an autoregressive structure and has to be positively correlated with past values.

More formally, let RP_t denote the natural logarithm of the sovereign country risk in day *t*, then we define the first differences of the country risk is defined as $\Delta RP_t = RP_t - RP_{t-1}$. Assuming ΔRP_t follows a process with the following characteristics:

$$\Delta RP_t = \mu + \varepsilon_t$$

$$\varepsilon_t \sim N\left(0, \sigma_t^2\right)$$

$$\sigma_t^2 = \omega + \alpha\ \varepsilon_{t-1}^2 + \beta\ \sigma_{t-1}^2$$

The unobservable variance of ΔRP_t is estimated through a GARCH(1,1) model and it is assumed ω, α and $\beta > 0$ in order to assure the non-negativity and stationarity of the unconditional variance process, that is, $\sigma_t^2 > 0$ and $\alpha + \beta < 1$. The specification of GARCH model is selected using the Bayesian Information Criterion (BIC). Additionally, the motivation to estimate a GARCH(1,1) model is associated with its advantage to describe the dynamics of the daily volatility of financial variables quite accurately (Bollerslev, 1986, Andersen *et al.*, 2013 and Palic *et al.*, 2017). Also, considering that the conditional variance is an unobservable variable, it must be estimated as well as the parameters that compose it. In this sense, the parameters values (that is, μ, ω, α and β) are estimated using the maximum likelihood method, which estimate the parameters of the GARCH model that are most likely to have generated the ΔRP_t series. Finally, once the conditional variance is obtained, the conditional standard deviation is computed, which will be used as a metric of the country risk volatility of Argentina.

3. Data

The sovereign spread is approximated through the Emerging Markets Bond Index (EMBI +) computed for Argentina calculated and disclosed by J. P. Morgan. The data for this indicator is taken from the newspaper Ámbito Financiero.[14] Moreover, the conditional variance of the country risk of Argentina is estimated

[14] https://www.ambito.com/

using the first difference of the natural logarithm of EMBI computed for Argentina. The model to be estimated considers that the country risk volatility of Argentina (*vol_embiarg*) is associated with non-traditional economic variables, which exploit the unstructured information disclosed in the press. In this sense, a database at quarterly frequency was developed, that covers the period 1998: Q1-2019: Q1. In turn, daily estimates of conditional volatility are transformed to quarterly frequency using the arithmetic mean, in order to obtain a series at quarterly frequency (Palic *et al.*, 2017).[15]

The second type of data is newspaper articles that are used to construct several non-traditional indicators that capture manifestations of different subjective states which are conjectured to be relevant. The procedure carried out to compute them has been detailed in the previous sections. The computed indicators are uncertainty, pessimism and fear. These three indexes correspond to those performed from the GloVe model, using the 50, 500 and 1000 words most strongly associated with each of these keywords. In order to compute a smoother measure for these indicators, the index constructed for the 50, 500 and 1000 words most associated with the keyword was averaged. In this way, the indicators *uncertainty_weighted, pessimism_weighted* and *fear_weighted* were obtained. Therefore, given the structure of these indicators, a higher value is associated with higher expectations of negative events regarding country risk indicators or more pessimistic views regarding this variable.

Figure 3 shows that the non-traditional economic indicators that capture important information regarding manifestations of uncertainty, pessimism and fear in the articles regarding the country risk topic, capture the evolution of the country risk volatility of Argentina (*vol_embiarg*). In particular, the notable increment in the three non-traditional indicators coincides with the international economic instability period at the end of the 1990s, which accelerated the surcharge paid by bonds issued in Argentina. Also, the indices capture the period of great country risk volatility after Argentina entered default (2001Q4), and increments are detected around the 2008-2009 international crisis and during the legal dispute between Argentina and the holdouts (2014Q3). Finally, figure 3 shows that the fear indicator seems to clearly capture the contemporary behavior of the country risk volatility of Argentina, while the pessimism and uncertainty indicators seem to favorably anticipate the future evolution of the country risk volatility of Argentina. In the Appendix B, the estimated densities of each series can be found.

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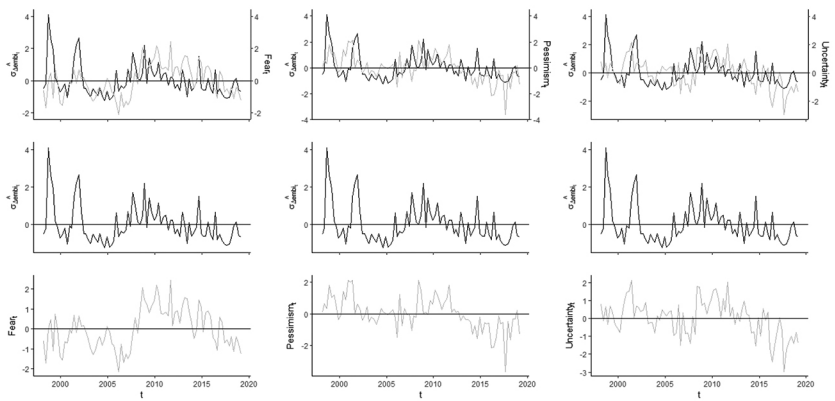
15 The days June 13rd, 2005 and June 30th, 2005, were excluded from the analysis due to their strong influence on the volatility indicator. This influence is associated with the substantial fall (-1.98 and -0.60, respectively) that shows the daily variation of the Argentine EMBI, calculated as the difference in logarithms. In the first case, the observed fall responds to the debt swap. In the second case, the observed fall responds to the exclusion of bonds in default in the computation of the Argentine EMBI.

FIGURE 3
COUNTRY RISK VOLATILITY OF ARGENTINA INDEX AND NON-TRADITIONAL INDICATORS BASED ON PRESS ARTICLES



Note: To facilitate comparisons, the time series were standardized.

Table 1 shows descriptive statistics for the variables used in this work. The table shows, first, that the average quarterly country risk volatility for the period was 2.9%. The period was characterized by high volatility as indicated by the standard deviation of, approximately, 1%. The country risk volatility reached its maximum sample value of 6.5% in September 1998, which is associated with the contagion effect produced by the Russian crisis that occurred in August of that year. In addition, the normality tests suggest the departure from normality, as measured by the test statistic, is statistically significant.

As shown in the following rows of table 1, the distribution of the non-traditional economic indicators based on unstructured information seem to differ from each other. In particular, the average quarterly for the period was 4%, which indicates that 4 out of every 100 words in the articles associated with the country risk topic manifest subjective states associated with pessimism, uncertainty or fear. Also, a certain asymmetry can be seen in the distribution of the indicators, but none is statistically significant. On the other hand, the pessimism and uncertainty indicator reached their maximum sample value in the second quarter of 2001 (2001:Q2), a quarter characterized by the negotiations associated with the *megacanje*, whose objective was to implement the external public debt restructuring. On the other hand, the fear indicator reached its maximum sample value in the third quarter of 2011 (2011:Q3). Also, non-traditional economic indicators show a volatile behavior throughout the analyzed period, which is deduced from their respective dispersion statistics (standard deviation and interquartile range). Finally, only the normality test of the pessimism index suggests the departure from normality is statistically significant.

Lastly, a measure that summarizes the information contained in the non-traditional indicators that capture manifestations linked to uncertainty, pessimism and fear is developed. In this sense, the variable *combined_indices* is constructed as the average of indexes: *uncertainty_weighted*, *pessimism_weighted* and *fear_weighted*. Table 1 shows that the *combined_indices* has a symmetric distribution, whose average value reaches 4%.

As we mentioned previously, the level of uncertainty is a non-observable concept. The empirical literature has developed several ways to proxies its behavior, such as the realized volatility of stock market returns (Bloom, 2009), the cross-sectional dispersion of subjective (survey-based) forecasts (Bachmann *et al.*, 2013), or the appearance of certain "uncertainty-related" key words in news publications (Baker et. al., 2016, Ghirelli *et al.*, 2019, Aromi, 2020). Therefore, one relevant question is: how does the performance of indices proposed in this paper compare to the performance observed with alternative methods? We consider five indicators to address this question: the volatility of stock market returns (*std_dev_merval*)[16], the disagreement in analyst forecasts about inflation rate and exchange rate (*disagreement_inflation* and *disagreement_er*, respectively)[17], an index that capture uncertainty in news articles regarding the country risk topic (*uncertainty_country_risk*)[18] and an index that capture uncertainty in news (uncertainty)[19].

Table 2 shows Pearson correlation coefficient between each indicator. There was a positive correlation between indexes proposed in this paper and indexes computed through alternative methods, except *fear_weigthted* that show a negative correlation with the variables that capture analyst forecast dispersion about inflation rate and exchange rate. Therefore, these results suggest that our indexes compare favorably with indices that capture uncertainty level using alternative methods.

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16 More specifically, the indicator is the standard deviation of the difference in logarithms of the daily S&P Merval, the Argentina stock market index. The sample period of these variables is 1998.Q1:2019.Q1. Source: https://es.finance.yahoo.com/.

17 More specifically, these indicators are the mean of the standard deviation for each variable, which are forecast by specialized analysts. We use the Market Expectations Survey (REM) by Central Bank. The sample period of these variables is 2016.Q2:2019.Q1. Source: http://www.bcra.gob.ar/.

18 More specifically, the indicator is the ratio between the number of articles that contain terms referring to two categories: uncertainty (we use the following list of words: "inciert*", "incertidumbr*", "inestabl*", "inestabilidad*") and country risk ("riesgo país", "riesgo pais", "embi"), and total of articles published in the newspaper La Nación.

19 More specifically, the indicator is the ratio between the number of articles that contain terms referring to uncertainty and total of articles published in the newspaper La Nación.

TABLE 1
DESCRIPTIVE STATISTICS

Sample period is 1998.Q1-2019.Q1. Data frequency is quarterly. vol_embiarg: country risk volatility of Argentina. fear_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "fear". uncertainty_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "uncertainty". pessimism_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "pessimism". combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted. Columns Skewness, Kurtosis and Jarque-Bera perform skewness test, kurtosis test, and Jarque–Bera test for the composite hypothesis of normality, respectively.

Variables	Mean	Median	St. Dev.	Q1	Q3	Minimum	Maximum	Skewness		Kurtosis		Jarque-Bera	
								Stat.	P-value	Stat.	P-value	Stat.	P-value
vol_embiarg	0.029	0.027	0.009	0.023	0.032	0.018	0.065	1.246	0.000	4.147	0.022	26.324	0.002
fear_weighted	0.035	0.034	0.006	0.031	0.039	0.023	0.049	0.220	0.38	2.374	0.164	2.048	0.259
uncertainty_weighted	0.043	0.044	0.004	0.04	0.046	0.031	0.052	-0.282	0.263	3.106	0.843	1.155	0.483
pessimism_weighted	0.039	0.038	0.005	0.036	0.041	0.022	0.048	-0.295	0.24	4.360	0.012	7.692	0.031
combined_indices	0.039	0.039	0.004	0.036	0.041	0.028	0.049	0.085	0.745	3.029	0.948	0.104	0.945

TABLE 2
CORRELATION COEFFICIENT BETWEEN UNCERTAINTY PROXIES

Sample period is 1998.Q1-2019.Q1. Data frequency is quarterly. fear_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "fear". uncertainty_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "uncertainty". pessimism_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "pessimism". combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted. std_dev_merval: stock market returns volatility of Argentina. disagreement_inflation: dispersion of inflation rate forecast, disagreement_er: dispersion of exchange rate forecast: uncertainty_country_risk: country risk uncertainty index. Uncertainty: uncertainty index.

	fear weighted	uncertainty weighted	pessimism weighted	combined indices
fear_weighted	1			
uncertainty_weighted	0.56	1		
pessimism_weighted	0.33	0.82	1	
combined_indices	0.78	0.92	0.82	1
std_dev_merval	0.22	0.16	0.11	0.20
disagreement_inflation	-0.21	0.00	0.40	0.14
disagreement_er	-0.27	0.11	0.37	0.15
uncertainty_country_risk	0.04	0.25	0.35	0.24
uncertainty	0.28	0.14	0.22	0.26

4. Estimation of contemporaneous association

In this section, an econometric exercise that evaluates the contemporary association between the country risk volatility of Argentina and a set of non-traditional economic indicators is carried out, conditional on other covariates. Understanding this association is useful, considering that country risk does play an important role in the dynamics of the economy of Argentina, the dynamics of the interest rate levels that Argentina faces in the international credit market, and the dynamics of certain real variables (Fernández-Villaverde *et al.*, 2011, de Ferra and Mallucci, 2020).

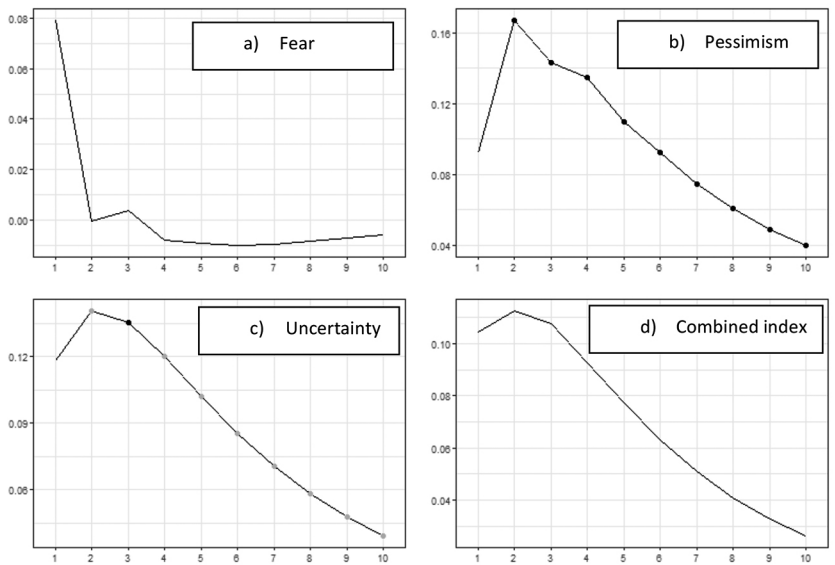
Following Ghirelli *et al.* (2019), we estimate Vector Autoregressive Models (VAR) for these variables in order to identify the effect of non-traditional indicator shock, which capture manifestations of subjective states associated with an expectation of negative events regarding the country risk topic. The VAR models is given by: $X_t = \Gamma(L)X_t + \varepsilon_t$, where X_t is a set of endogenous variables, Γ is a matrix of VAR coefficients capturing the dynamics of the system, and $\varepsilon_t \sim N(0,\Omega)$ is the vector of reduced-form residuals having zero-mean and variance-covariance matrix Ω .The VAR models are estimated by OLS. In each model, we include lags according to the optimal lag length.

To identify shocks we impose the following ordering for the Cholesky decomposition: the volatility of country risk (*vol_embiarg*) was put first, assuming that it is highly probable that this variable can have a contemporaneous effect

on the non-traditional indicators in the system, while the opposite is much less probable. The country risk volatility of Argentina is then followed by a non-traditional indicator.

Figure 3 compares the responses of the country risk volatility of Argentina for an unexpected shock in the indicator that capture manifestations of fear, uncertainty, and pessimism in articles regarding the country risk topic and the variable that combined these indices.[20]

FIGURE 4
RESPONSE TO NON-TRADITIONAL INDICATORS



Note: Each graph shows responses to a positive shock of one standard deviation in a non-traditional indicator. Black (gray) circles indicate statistical significance at 5 (10)%; solid line, no statistical significance.

Looking at impulse-response functions, a first striking result is the positive response of the country risk volatility of Argentina to changes in the non-traditional indicators proposed in this paper. In particular, an unexpected increase in pessimism generates a significant increase in the country risk volatility of Argentina, which is persistent. The initial increase amounts to about 0.167 standard

[20] Results are robust to: i) modeling different VAR lags; ii) ordering country risk volatility indicator last in the vectors, to control for possible contemporaneous effects of the non-traditional indicators on country risk volatility indicator. See Figure C.1 and C.2 in the Appendix C.

deviations in the second quarter, and gradually fades away. On the contrary, the response of volatility of country risk to shocks to the fear indicator is positive but weak and non-statistically significant, while the response to shocks to the combined indicator is positive and persistent but non-statistically significant.

The results shown in this section allow us to conclude that the levels of certain non-traditional indicators contain valuable information about the future evolution of the country risk volatility of Argentina. In this sense, as previously mentioned, the pessimism and uncertainty indicators seem to capture notably the dynamics behavior of the country risk volatility regarding the fear indicator.

5. Forecast country risk volatility

The future levels of the country risk volatility are a source of information whose relevance is essential for the design of economic policy. The relevance of understanding the dynamics of the country risk volatility lies in the strong relationship between this variable and the interest rate that countries face in the international capital market and the dynamics of certain real variables (Fernández-Villaverde *et al.*, 2011, de Ferra and Mallucci, 2020). Additionally, a growing set of studies shows favorable results when incorporating indicators based on unstructured information as predictors in models that aim to predict economic phenomena (Tetlock, 2007, García, 2013, Loughran and McDonald, 2011, Baker *et al.*, 2016, Ghirelli *et al.*, 2019, Aromi, 2020). Therefore, this section performs several forecasting exercises in order to evaluate the informational content of a set of non-traditional indicators regarding the future dynamics of the country risk volatility of Argentina. In this sense, the extent to which non-traditional indicators are able to contribute to improve our understanding of the dynamics of these phenomena, inherent in economies exposed to frequent uncertainty shocks such as the Argentine economy, is evaluated.

5.1. In-sample forecast

In this section, the information content of the non-traditional indicators based on unstructured information is evaluated through a series of in-sample forecasting exercises. The informative content of the non-traditional indicators and its ability to anticipate country risk volatility is evaluated. The forecasting models are given by an autoregressive specification that is complemented with an indicator of lagged press content. This model allows us to evaluate the information content of the proposed indicators, conditional on the other covariates' information. The number of lags is selected minimizing the Bayesian Information Criterion (BIC).

More formally, let $\sigma_{\Delta r_t}$ be the country risk volatility of Argentina (*vol_embiarg*) in quarter t, approximated by the conditional standard deviation estimated from the GARCH(1,1) model. The baseline autoregressive model satisfies:

$$\sigma_{\Delta r_t,t+h} = \alpha + \sum_{s=0}^{P} \beta_s \sigma_{\Delta r_t,t-s} + \mu_{t+h}$$

where P is the number of lags and $\mu_{t+h} \sim N\left(0,\sigma_i^2\right)$ is the forecast error, which follows a white noise process. In turn, the predictive ability of press content is evaluated through extended models that incorporate, as a predictor, one of four specifications of the non-traditional indicators. Formally, the forecasting models used to estimate the information content of non-traditional indices based on press content are given by the following equation:

$$\sigma_{\Delta r_t,t+h} = \alpha + \sum_{s=0}^{P} \beta_s \sigma_{\Delta r_t,t-s} + \beta_I I_t + \mu_{t+h}$$

where I_t can be one of the four non-traditional indicators that exploit unstructured information regarding country risk topic published in the press. The parameter of interest is β_1. If $\beta_1 = 0$, the baseline model is estimated, while otherwise we estimate an extended forecast model which incorporates only one proposed regressor, namely: *uncertainty_weighted*, *pessimism_weighted*, *fear_weighted* or *combined_indices*. Also, the relative metric of model fit, as indicated by increments in *Adjusted* R^2, is analyzed to assess the in-sample forecasting performance of the indicator. This metric allows us to compare how the benchmark model performs with the performance of the extended model. The predictors are standardized to facilitate the comparison of the economic significance of different estimated parameters. Finally, in order to capture the higher uncertainty derived from incorporate generated variables as regressors, residuals bootstrap is implemented (Berkowitz & Kilian, 2000)[21].

Table 3 shows the estimations of the different specifications of the forecasting models. Column 1 shows the baseline model, while the following columns show the extended model. The baseline models indicate that lagged quarterly country risk volatility is statistically and economically significant predictor of country risk volatility. First, column 1 shows that the country risk volatility process contains an inertia component. Additionally, column 1 shows that the intercept is positive and statistically significant, which indicates that the country risk volatility reaches values of around 3% even when the value of the covariates is equal to zero. These results are in line with those reported in the previous sections. Finally, *Adjusted* R^2's suggest that these variables contain substantive information regarding subsequent levels of the country risk volatility of Argentina.

The estimated extended models indicate that press content adds information regarding future country risk volatility levels. Column 1 shows that the indicator that captures manifestations of fear does not seem to contain relevant information on the future evolution of the country risk volatility. In this sense, the fear

[21] Taking into account that residuals bootstrap fails for time-dependent data, we implemented this method after to check there is no autocorrelation in the residuals.

indicator is able to provide information regarding the contemporary evolution of country risk volatility (see table 2), while displaying limitations to anticipate the future levels of the country risk volatility of Argentina. Second, columns 3 and 4 show the results associated with the extended model that incorporates the indicator of pessimism and uncertainty, respectively. Those models suggest that increases in the levels of pessimism and uncertainty in newspaper articles regarding the country risk topic anticipate increases in future country risk volatility levels. In particular, a one standard deviation increment in the pessimism index anticipates, on average, an increment of 0.4% in country risk volatility over the next quarter. In other words, a one standard deviation increment in the pessimism index anticipates, on average, an increment of 0.21 standard deviations in country risk volatility over the next quarter. This effect is not economically negligible if the estimated coefficient associated with the indicator of lagged country risk volatility is considered. Additionally, *Adjusted* R^2's point to noticeable gains in anticipatory ability. For example, in the baseline model, the *Adjusted* R^2 increases from 0.25 to more than 0.28 and 0.27 as the pessimism and uncertainty indicator are incorporated as predictors, respectively (see column 3 and 4). Lastly, the

TABLE 3
FORECASTING MODELS

Sample period is 1998.Q1-2019.Q1. Data frequency is quarterly. vol_embiarg: country risk volatility of Argentina. fear_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "fear". uncertainty_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "uncertainty". pessimism_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "pessimism". combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted.

	(1)	(2)	(3)	(4)	(5)
vol_embiarg_t	0.005***	0.005***	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
fear_weighted_t		-0.001			
		(0.001)			
pessimism_weighted_t			0.002**		
			(0.001)		
uncertainty_weighted_t				0.002**	
				(0.001)	
combined_indices_t					0.001
					(0.001)
Constant	0.029***	0.029***	0.029***	0.029***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	84	84	84	84	84
R^2	0.264	0.267	0.304	0.295	0.279
Adjusted R^2	0.255	0.249	0.287	0.277	0.261
F Statistic	29.456 ***	14.776***	17.685***	16.910***	15.671***

Note: nonparametric bootstrapped standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

indicator that combines the information from the three indicators that exploit the content published in the press does not seem to capture valuable information regarding the dynamics of country risk volatility (see column 5).

The results of the present subsection show that indicators based on unstructured information regarding country risk topic provide valuable information regarding future levels of the country risk volatility of Argentina. In particular, the results suggest that models which incorporate indicators that capture manifestations of pessimism and uncertainty add valuable information regarding future levels of the country risk volatility of Argentina and improve upon baseline forecasts by increasing 3 percentage points the *Adjusted* R^2. However, the indicator that captures manifestations of fear and the indicator that combines the information from non-traditional indices seem to be unable to capture valuable information regarding future country risk volatility levels. These results are consistent with those results reported in section 4.

5.2. Out-of-sample forecast

To provide further insights on the information content of press media we implement out of sample forecasts exercises in which models are trained recursively with past information. The performance of forecast generated by the baseline autoregressive model is compared to forecasts produced by models that incorporate an additional predictor. Four predictors are considered: *uncertainty_weighted*, *pessimism_weighted*, *fear_weighted*and*combined_indices.*

In this subsection, the predictive ability of non-traditional indicators on the country risk volatility of Argentina will be evaluated. As previously mentioned, this work aims to evaluate the information content of the regressors proposed regarding future levels of the country risk volatility. In this sense, positive results are observed in previously reported in-sample forecast exercises (see section 5.1). In order to evaluate the marginal contribution of each predictor based on unstructured information, we implement out-of-sample forecast exercise. In turn, the aim of this subsection is not to find the best forecasting model, but to evaluate the predictive ability of each regressor. In this sense, the predictive power of each regressor will be evaluated based on its ability to increase the forecast accuracy, which will be evaluated from the gain in terms of reduction of the two proposed objective measures, the RMSE and MAE (Faust and Wright, 2013).

Each forecast model is evaluated computing the root-mean-square prediction error (RMSE) and the mean absolute error (MAE). For extended models these measure of accuracy is also expressed as a fraction of the RMSE (and the MAE) of the baseline model. The benchmark is in the denominator so that numbers less than one indicate that the alternative model outperforms the benchmark. The baseline model is given by an autoregressive model, while the extended model is given by the autoregressive specification that is complemented with an indicator of lagged press content (see section 5.1). The performance of the models is assessed by using a specific starting date for pseudo out-of-sample forecast exercise. The starting dates are selected so that the smallest training

subsample represents 80% of the full sample. Following Faust *et al.* (2013), resampling techniques are implemented to compute the statistical significance of the differences in accuracy.

Following Faust *et al.* (2013) the bootstrap resampling techniques is used to approximate the distribution of the Diebold-Mariano statistic under the null hypothesis. The Bootstrap exercise follows the following steps. We estimate two models: (a) a restricted model that involves estimating an AR(4) process for *vol_embiar* g_t and (b) an unrestricted model that consists of a regression of *vol_embiar* g_t on four lags of itself and three predictors: the first three main components that capture the greatest variability of the set of regressors used in this work. In each bootstrap replication (500 replications), we then resample the residuals of the unrestricted model using wild bootstrap and construct a bootstrap sample of *vol_embiar* g_p_t using these resampled residuals, together with the coefficients from the restricted model.

Table 5 shows the results for out-of-sample forecast exercises. For some extended models, the estimated forecast accuracy is higher than that observed in the case of the baseline model. In this sense, three of the four proposed indicators (*weighted_ pessimism, weighted_ uncertainty* and *combined_indices*) contain useful information that allows improving performance in forecasting the country risk volatility. These differences are statistically significant in all cases. However, the fear indicator does not seem to capture valuable information beyond

TABLE 4
OUT-OF-SAMPLE FORECAST

Sample period is 1998.Q1-2019.Q1. Data frequency is quarterly. vol_embiarg: country risk volatility of Argentina. fear_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "fear". uncertainty_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "uncertainty". pessimism_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "pessimism". combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted. The forecast combination models are done through simple forecast averages. In this sense, combination_A combines the extended forecast models that incorporate fear_weighted, pessimism_weight, uncertainty_weighted and combined_indices, while combination_B averages the baseline forecast model and the extended forecast models.

	RMSE	RATIO	p-value	MAE	RATIO	p-value
base	0.00585			0.00510		
fear_weighted	0.00583	0.996	[0.260]	0.00508	0.996	[0.316]
pessimism_weighted	0.00542	0.926	[0.034]	0.00446	0.874	[0.018]
uncertainty_weighted	0.00511	0.873	[0.010]	0.00426	0.835	[0.014]
combined_indices	0.00552	0.943	[0.058]	0.00468	0.918	[0.05]
combination_A	0.00525	0.898	[0.006]	0.00435	0.853	[0.008]
combination_B	0.00533	0.911	[0.006]	0.00450	0.883	[0.014]

Note: forecast combinations are implemented through simple averages. p-values in brackets.

what the autoregressive model communicates. The result associated with the fear indicator is consistent with those results observed in the in-sample forecast exercise (see section 5.1). On the other hand, it is worth noting that the results obtained from the models that incorporate the indicator *combined_indices* in the out-of-sample estimation differ from those presented in section 5.1. The last two rows of the table show that forecast combinations allow for further gains in accuracy. In summary, these out-of-sample forecast exercises provide further support to the idea that press content regarding country risk topic provides valuable information regarding future levels of the country risk volatility of Argentina.

6. Robustness analysis

This section aims to carry out a set of robustness exercises that provides evidence to strengthen the patterns documented in this work. Therefore, this section is organized as follows. First, in-sample forecast exercises where the country risk volatility indicator is approximated by an alternative methodology are carried out. Second, a set of traditional economic indicators are incorporated into the in-sample forecast model. Third, it evaluates whether the effects of non-traditional indicators intensify during periods of high volatility. Fourth, non-traditional indicators based on new content published by other press media, namely: Página 12 and Ámbito Financiero, are incorporated into in-sample forecast model. Finally, new countries are incorporated, namely: Brazil, Chile and Peru.

6.1. An alternative volatility measures

This section proposes a new way of modeling volatility, the interest variable in this work, as a robustness exercise. In this sense, the mean of the standard deviation of the difference in logarithms of the daily Argentine country risk (Δr_t), approximated by the EMBI index computed for Argentina, is considered as a measure of volatility in quarter t. In this way, we hope that the relationship between the country risk volatility and non-traditional indicators based on unstructured information about the country risk topic will remain. The number of lags is selected minimizing the Bayesian Information Criterion (BIC).

Table 5 shows the results for in-sample forecast exercises, proposed in section 5.1, using a new volatility metric. The baseline and extended models indicate that both lagged quarterly country risk volatility and intercept are statistically and economically significant predictors of the country risk volatility of Argentina. On the other hand, some indicators based on unstructured information published by the press seem to capture valuable information regarding future evolution of the country risk volatility. Finally, *Adjusted* R^2's suggest that these variables contain substantive information regarding subsequent levels of country risk volatility, which was computed by a new methodology.

Therefore, in this subsection it can be seen that, in general, the set of proposed regressors has a statistically significant association with the variable of

interest in this work. The results are consistent with those reported in section 5.1. In this sense, the regularities reported in this subsection allow not only to strengthen the associations between the variables, but also to make these associations independent from the methodology used to estimate the dependent variable, the volatility of the country risk.

Summarizing, the evidence reported above suggests that indices based on press content have valuable information regarding future levels of the country risk volatility of Argentina. These findings are robust to changes in the methodology used to estimate the dependent variable, the country risk volatility. These results are consistent with those results reported in table 3.

TABLE 5
FORECASTING MODELS USING AN ALTERNATIVE MEASURE OF VOLATILITY

Sample period is 1998.Q1-2019.Q1. Data frequency is quarterly. vol_embiarg: country risk volatility of Argentina using a new methodology. fear_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "fear". uncertainty_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "uncertainty". pessimism_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "pessimism". combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted.

	(1)	(2)	(3)	(4)	(5)
vol_embiarg_t	0.005***	0.006***	0.005***	0.005***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
fear_weighted_t		-0.001			
		(0.001)			
pessimism_weighted_t			0.002**		
			(0.001)		
uncertainty_weighted_t				0.002**	
				(0.001)	
combined_indices_t					0.001
					(0.001)
Constant	0.026***	0.026***	0.026***	0.026***	0.026***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	84	84	84	84	84
R^2	0.238	0.242	0.277	0.267	0.252
Adjusted R^2	0.229	0.224	0.259	0.249	0.233
F Statistic	25.679***	12.950***	15.492***	14.739***	13.637***

Note: nonparametric bootstrapped standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01

6.2. In-sample forecast considering traditional indicators

This subsection seeks to evaluate the extent to which the information provided by non-traditional indicators is different from that provided by traditional economic indicators. In this sense, the explanatory capacity of traditional economic

indicators versus the predictive capacity of indicators based on unstructured information published in the press can be evaluated. Additionally, the evaluation of these economic indicators allows a potentially more precise description of the phenomenon analyzed.

Following the literature on the determinants of the country risk premium several indicators related to macroeconomic aggregates, intertemporal liquidity, contagion effects, and external shocks are incorporated (Edwards, 1985, Kieguel and Lopetegui, 1997, Nogués and Grandes, 2001, Rowland, 2004, Uribe and Yue, 2006, Azar *et al.*, 2007, Grandes, 2007, González-Rosada and Levi Yeyati, 2008, Bellas *et al.*, 2010, Csonto and Ivasckenko, 2013, Mpapalika and Malikane, 2019). In particular, the ratio between international reserves[22] and GDP[23], the ratio between external debt[24] and GDP, national interest rate[25], the EMBI+ index computed for emerging countries[26] and the EMBI+ index computed for Argentina[27]. These indicators allow us to capture country's internal and external economic situation, as well as its liquidity and solvency conditions. The sources of data are the Central Bank[28] (BCRA), the official open data site[29], and Ámbito Financiero[30]. Most of these indicators are available on a monthly basis. Hence, a transformation into quarterly data is necessary. Taking into account the statistical behavior of the series, we transform our data to obtain stationary time series[31]: both EMBI+ index computed for emerging countries and EMBI+ index computed for Argentina. Lastly, we use the natural logarithm of the national interest rate.

Table 6 shows the results for in-sample forecast exercises[32], proposed in section 5.1, incorporating a new metric as a regressor: *traditional_indices*. In order to summarize economic information provided by traditional economic indicators, a Principal Component Analysis (PCA) method is implemented. Therefore, the indicator *traditional_indices* correspond to the first principal component which accounts for most variance in the set of traditional economic regressors used in this work. Columns 1 to 5 show that the estimated coefficient

22 Quarterly average of monthly balances at the end of the month (in millions of dollars).
23 Gross Domestic Product (GDP) interpolated current (in dollars).
24 Total external debt of Public sector and Central Bank from an estimate of gross external debt by resident sector at market value. Quarterly average of monthly of the balances at the end of the month (in millions of dollars)
25 Quarterly average of monthly interest rate, which corresponds to 30- through 59-day term deposits. We decided to use interest rates for term deposits because in the case of Argentina, there is no interest rate that was used consistently as an instrument of monetary policy during the period under analysis.
26 Quarterly average of monthly EMBI+ values for emerging countries.
27 Quarterly average of monthly EMBI+ values for Argentina
28 http://www.bcra.gov.ar/
29 https://www.argentina.gob.ar/modernizacion
30 https://www.ambito.com/
31 We conduct the Augmented Dickey-Fuller and Phillips-Perron unit-root test.
32 The number of lags is selected minimizing the Bayesian Information Criterion (BIC).

associated with the traditional indicator carries the expected positive sign. However, this variable does not seem to contain information to explain the future evolution of the country risk volatility of Argentina. Additionally, the estimated coefficient remains mostly unaltered as an indicator that summarizes economic information is incorporated into the model. These results suggest that the indicators that capture different manifestations of subjective states in the content of the press provide valuable information that is different from that provided by traditional economic indicators.

Summarizing, the evidence reported above suggests that indices based on press content have valuable information regarding future levels of the country risk volatility of Argentina. These findings are robust to changes in the set of predictors. These results are consistent with those results reported in table 3.

TABLE 6
NON-TRADITIONAL INDICES VS. TRADITIONAL VARIABLES

Sample period is 1998.Q1-2019.Q1. Data frequency is quarterly. vol_embiarg: country risk volatility of Argentina. fear_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "fear". uncertainty_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "uncertainty". pessimism_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "pessimism". combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted. traditional_indices_t: first principal component which accounts for most variance in the set of traditional economic regressor proposed.

	(1)	(2)	(3)	(4)	(5)
vol_embiarg_t	0.005***	0.005***	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
fear_weighted_t		-0.0004			
		(0.001)			
pessimism_weighted_t			0.002**		
			(0.001)		
uncertainty_weighted_t				0.002**	
				(0.001)	
combined_indices_t					0.001
					(0.001)
traditional_indices_t	0.0007	0.0006	0.0001	0.0004	0.0006
	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)
Constant	0.029***	0.029***	0.029***	0.029***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	84	84	84	84	84
R^2	0.269	0.271	0.304	0.296	0.283
Adjusted R^2	0.251	0.243	0.278	0.270	0.256
F Statistic	14.922***	9.90***	11.651***	11.221***	10.517***

Note: nonparametric bootstrapped standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

6.3. In-sample forecast considering interactions

The model proposed in section 4 assumes that the relationships between two explanatory variables do not change their relationships with the dependent variable. An interesting empirical exercise consists in considering a model in which the estimated associations can take different values according to the economic conditions. In this sense, a conjecture is that volatility levels are related to information volume. During turbulent periods, the dissemination and scope of news is greater, since economic agents are more willing to incorporate information, review their beliefs and modify behaviors (Gorodnichenko, 2008, Coibion and Gorodnickenko, 2012), which induces an effect expected higher on volatility levels. More specifically, we are interested in estimating a model in which the estimated coefficients can take different values in periods of low volatility and periods of high volatility. This exercise serves as a robustness check of the exercises developed in section 5.1.

The estimation methodology involves computing a dummy variable (D_t) that takes a value of one if quarter t was classified as higher volatility period (the level of volatility in period t is greater than one standard deviation of the mean volatility level in period t-1) and takes a value of zero otherwise. This variable is used to estimate a flexible model in which different slopes are allowed for depending on the level of volatility level in period t-1.Thus, 13 quarters result in periods of high volatility (13% of the sample quarters), while the rest of the quarters correspond to periods of low volatility. This variable is used to estimate the following model:

$$\sigma_{\Delta r_t,t+1} = \alpha + \beta_1 \sigma_{\Delta r_t,t} + \beta_2 I_t + \beta_3 D_t + \beta_4 D_t I_t + \mu_{t+1}$$

In other words, in this section we allow the coefficient associated with the non-traditional indicators of the model proposed in section 5.1 to take different values according to the volatility levels of the past period. The results are shown in table 7. The number of lags is selected minimizing the Bayesian Information Criterion (BIC).

Table 7 shows the results for in-sample forecast exercises, proposed in section 5.1, incorporating a term that captures the interaction of non-traditional indicators with a dummy of high country risk volatility in quarter t-1. In all cases, the estimated coefficients associated with the interaction variable are positive and not significant. That is, the effects of non-traditional indicators on future country risk volatility do not intensify during periods of high volatility. Additionally, the coefficient that captures the levels of volatility conditional on the value of the independent variables being zero is not higher in periods of high volatility than the level observed when the level of volatility is low.

In summary, the results reported in this subsection are in line with the patterns documented throughout this work. In particular, this subsection shows that indices based on press content have valuable information regarding future

levels of the country risk volatility of Argentina. In turn, there is no statistically significant evidence to conclude that these effects intensify during periods of high volatility. Finally, an analysis of the robustness of this exercise indicates that the results are not sensitive to variations in the definition of high volatility period.[33]

TABLE 7
NON-LINEAR MODELS

Sample period is 1998.Q1-2019.Q1. Data frequency is quarterly. vol_embiarg: country risk volatility of Argentina. fear_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "fear". uncertainty_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "uncertainty". pessimism_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "pessimism". combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted. dummy: variable that takes a value one if quarter t was classified as higher volatility period and zero otherwise. interaction: variable that allow a non-traditional indicator takes different value according to the volatility levels of the past period.

	(1)	(2)	(3)	(4)
vol_embiarg_t	0.005***	0.004***	0.005***	0.005***
	(0.002)	(0.001)	(0.001)	(0.001)
fear_weighted_t	-0.0003			
	(0.002)			
pessimism_weighted_t		0.002**		
		(0.001)		
uncertainty_weighted_t			0.002*	
			(0.001)	
combined_indices_t				0.001
				(0.001)
β_{dummy}	-0.0001	-0.001	-0.002	-0.002
	(0.007)	(0.004)	(0.004)	(0.005)
$\beta_{interaction}$	-0.003	0.0001	0.0002	0.0002
	(0.005)	(0.004)	(0.004)	(0.004)
Constant	0.029***	0.029***	0.029***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	84	84	84	84
R^2	0.279	0.309	0.296	0.280
Adjusted R^2	0.242	0.274	0.261	0.244
F Statistic	7.635***	8.839***	8.314***	7.697***

Note: nonparametric bootstrapped standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

[33] The model proposed in this subsection was estimated by alternatively defining the dummy variable that captures periods of high volatility. First, periods of high volatility were considered those quarters in which the country risk was greater than 1000 basis points. Second, periods of high volatility were considered those quarters in which the level of country risk volatility in quarter t was higher than the mean volatility level during period t-1. Third, the quarters in which Argentina was in default (2001Q-2005Q2 and 2014Q3-2016Q2) were considered as high volatility periods.

6.4. In-sample forecast incorporating new unstructured content

This work studies to what extent non-traditional economic indices based on natural language processing techniques capture valuable information regarding the future levels of the country risk volatility of Argentina. The indicators were built based on a corpus of articles regarding the country risk topic, which were identified through an unsupervised machine learning (LDA) method as mentioned in detail in subsection 2.1. The press articles correspond to the economics section of the newspaper La Nación. Therefore, an interesting exercise could be to incorporate content published in other media. This exercise provides an informative and coherent description of the patterns documented in this work.

The trained model in section 2.1 is applied to the economics section of the newspaper Página 12 (available from 2002:Q1) and Ámbito Financiero (available from 2009:Q1) in order to identify those articles regarding the country risk topic (topics 7 and 47). Once the articles have been identified, the same set of quantitative indicators that captures different manifestations of subjective states is constructed by using the closely associated words to a keyword which are identified by the GloVe model, described in section 2.2.

Table 8 shows the results for in-sample forecast exercises[34], proposed in section 5.1, incorporating the indicators proposed in this work, which combine the information from the articles of the newspaper La Nación, Ámbito Financiero and Página 12. Therefore, the indicators developed in this section capture different manifestations of subjective states in the articles regarding the country risk topic published by three Argentine newspapers with national coverage. The information is combined by averaging the standardized newspaper-level series.[35] In consistency with the previously reported results, the estimated extended models indicate that press media content adds information regarding future levels of the country risk volatility of Argentina. These findings are robust to changes in the corpus used to develop the predictors.

[34] The number of lags is selected minimizing the Bayesian Information Criterion (BIC).

[35] More specifically, the indicators of interest are computed for each newspaper, then these are standardized (each regressor is standardized subtracting its sample mean and dividing the difference by its sample standard deviation) and, finally, the average is taken. This way of combining information responds to the overall volume of articles varies across newspapers and time. In particular, the average number of articles published in the economics section of the newspaper Página 12 throughout the period analyzed reaches 533 articles (on average, 31 articles regarding the country risk topic), while this number rises to 1913 articles (80 deal with the topic of interest) for the newspaper La Nación and 1510 articles for the newspaper Ámbito Financiero (57 correspond to the country risk topic).

TABLE 8
FORECASTING MODELS INCORPORATING NEW UNSTRUCTURED CONTENT

Sample period is 1998.Q1-2019.Q1. Data frequency is quarterly. vol_embiarg: country risk volatility of Argentina. fear_weighted: is the "fear" indicator using new contents. uncertainty_weighted is the "uncertainty" indicator using new contents. pessimism_weighted: is the "pessimism" indicator using new contents. combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted. The non-traditional indicators were generated using Ámbito Financiero, La Nación, and Página 12 newspapers.

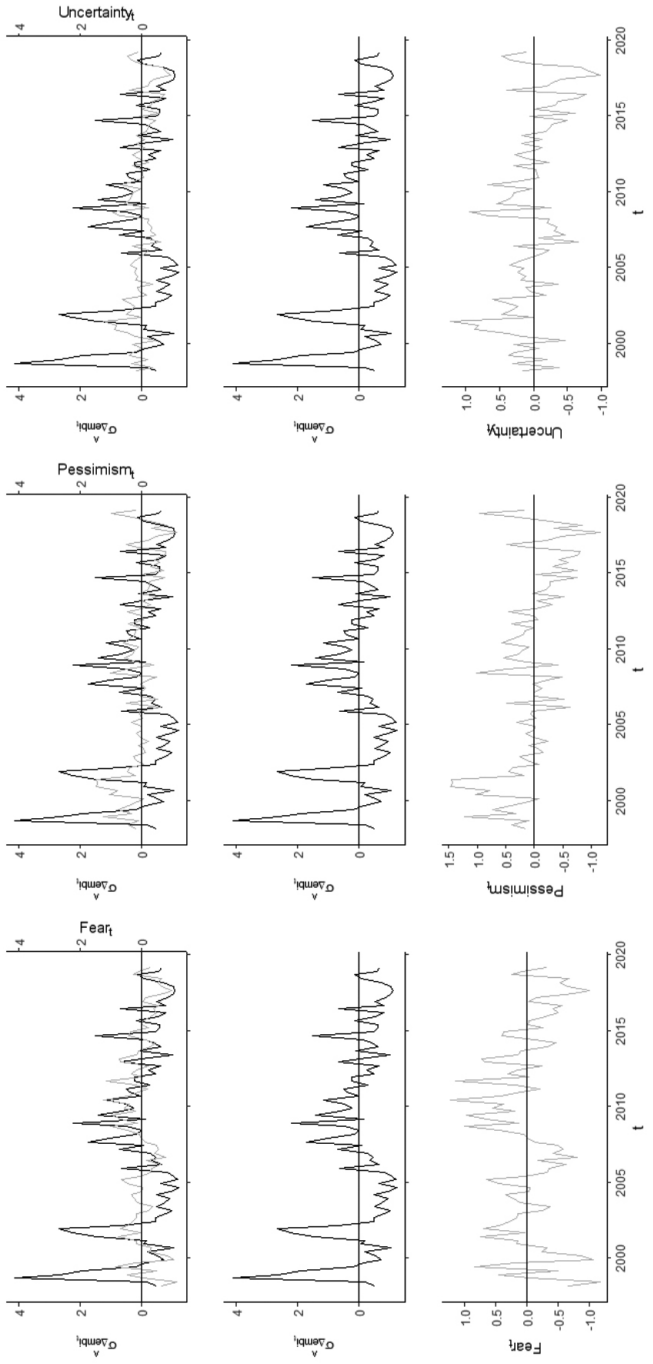
	(1)	(2)	(3)	(4)	(5)
vol_embiarg_t	0.005***	0.005***	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
fear_weighted_t		-0.001			
		(0.001)			
pessimism_weighted_t			0.002*		
			(0.001)		
uncertainty_weighted_t				0.002**	
				(0.001)	
combined_indices_t					0.002
					(0.003)
Constant	0.029***	0.029***	0.029***	0.029***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	84	84	84	84	84
R^2	0.264	0.274	0.293	0.305	0.269
Adjusted R^2	0.255	0.256	0.276	0.288	0.251
F Statistic	29.456***	15.286***	16.808***	17.790***	14.905***

Note: nonparametric bootstrapped standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Finally, Figure 2 provides further evidence on the co-movement of the country risk volatility of Argentina and the non-traditional indicators based on the newspaper articles regarding country risk topic published by the newspapers La Nación, Ámbito Financiero, Financiero and Página 12. The incorporation of new press content can result in more precise non-traditional indicators. Figure 2 shows these non-traditional indicators based on economic information published in press media contain information regarding the evolution of the country risk volatility of Argentina.

According to the evidence reported above, non-traditional indicators that capture manifestations of subjective states are consistently associated with the country risk volatility of Argentina. More specifically, the increase in the indicators that capture manifestations of fear, pessimism and uncertainty are positively associated with future country risk volatility levels. The incorporation of new unstructured content not only allows reinforcing the regularities reported in previous sections but also makes these findings are robust to changes in the corpus used to develop the non-traditional indicators proposed in this work. These results are consistent with those results reported in table 3.

FIGURE 5
COUNTRY RISK VOLATILITY OF ARGENTINA INDEX AND NON-TRADITIONAL INDICATORS BASED ON PRESS ARTICLES PUBLISHED BY THREE NEWSPAPERS



Note: To facilitate comparisons, both time series were standardized.

6.5. In-sample forecast incorporating other countries: Brazil, Chile and Peru

This work studies to what extent non-traditional economic indices based on natural language processing techniques capture valuable information regarding the future levels of the country risk volatility of Argentina. However, an interesting exercise could be to incorporate other countries into the analysis. In this sense, three Latin American countries, Brazil, Chile and Peru, are incorporated into the analysis in order to assess whether the regularities reported in this work are found in economies with structural and socio-demographic characteristics similar to the Argentine economy. The choice of these countries is linked to the availability of historical digitized information.

The trained model in section 2.1 is applied to the economics section of the newspaper El Mercurio of Chile[36] (available from 2010: Q1) and El Comercio of Peru[37] (available from 2013: Q1) in order to identify those articles regarding the country risk topic (topics 7 and 47). Once the articles have been identified, the same set of quantitative indicators that captures different manifestations of subjective states is constructed using the closely associated words to a keyword which are identified by the GloVe model, described in section 2.2. On the other hand, a different methodology was followed for Brazil since its official language is Portuguese. In the Brazilian case, the indicators of uncertainty, pessimism and fear are based on economics section articles published in the newspaper Folha do São Paulo[38] (available from 1999:Q4) that contain at least one term associated with the country risk topic[39] in an article, following the methodology proposed in section 2.2.2.[40] In turn, the country risk volatility of each country is estimated by following the methodology proposed in section 2.3, where the sovereign spread is approximated through the Emerging Markets Bond Index[41] (EMBI +), calculated and disclosed by J.P. Morgan, computed for Brazil, Chile and Peru. The EMBI+ data for Brazil was taken from the newspaper Ámbito Financiero[42], while the data for Chile and Peru comes from the Central Bank of Chile[43].

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36 https://www.emol.com/buscador/?query=econom%C3%ADa

37 https://elcomercio.pe/archivo/

38 https://acervo.folha.com.br/index.do

39 The corpus associated with the country risk topic is made up of those articles that contain at least one of the followings terms “risco-país”, “risco país”, “Risco-país”, “Risco-País”, “Risco País”, “EMBI+” or “EMBI”.

40 In this case, the list of words associated with the term uncertainty is: incerteza, confusão, dubiedade, ambiguidade, dúvida, dubiez, hesitação, imprecisão, indecisão, indefinição, indeterminação, insegurança, interrogação, irresolução, oscilação, perplexidade, vacilação, incerto, imprevisibilidade, incertezas, incerta, incertas, incertos, incertamente, incertar, inseguro, duvidoso, desconfiar, diagnóstico, ruído, vulnerável. The list of words used for the term pessimism is: pessimismo. Finally, the list of words associated with fear is: medo, rumores, desconfiar, suposto, considerar, pânico, avisar, dúvida, negar.

41 Quarterly average of monthly EMBI+ values for Chile and Peru.

42 https://www.ambito.com/contenidos/riesgo-pais-brasil-historico.html

43 https://si3.bcentral.cl/siete

Table 9, 10 and 11show the results for in-sample forecast exercises[44], proposed in section 5.1, for each country, namely Brazil, Chile and Peru, respectively. On the one hand, the intercept is positive and statistically significant, which indicates that the country risk volatility reaches values of around 2.7% for Brazil, 2.4% for Chile and 2.7% for Peru even when the value of the covariates is equal to zero. These coefficients are also positive and statistically significant even when the model specification changes. On the other hand, the estimated models indicate that a one standard deviation increment in the indicator of volatility anticipates a mean increment of approximately 0.5, 0.2 and 0.1% in the volatility indicator over the next quarter for Brazil, Chile and Peru, respectively. The estimated coefficient associated with the indicator of lagged country risk volatility for Brazil is similar to that reported for Argentina, while this estimated coefficient for Chile and Peru is lower than the estimated coefficient for Argentina and non-statistically significant (see table 3). Finally, the indicators that capture different manifestations of subjective states have valuable information regarding future levels of country risk volatility for Brazil (whose estimated coefficients are similar to those reported for Argentina). However, non-traditional indicators do not seem to capture valuable information regarding future levels of country risk for Chile and Peru beyond what the autoregressive model communicates.

TABLE 9
FORECASTING MODEL FOR BRAZIL

Sample period is 1999.Q4-2019.Q1. Data frequency is quarterly. vol_embiarg: country risk volatility of Brazil. fear_weighted: is the "fear" indicator. uncertainty_weighted: is the "uncertainty" indicator. pessimism_weighted: is the "pessimism" indicator. combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted.

	(1)	(2)	(3)	(4)	(5)
vol_embibra_t	0.005***	0.004***	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
fear_weighted_t		0.002**			
		(0.001)			
pessimism_weighted_t			0.003***		
			(0.001)		
uncertainty_weighted_t				0.003***	
				(0.001)	
combined_indices_t					0.003***
					(0.001)
Constant	0.026***	0.027***	0.027***	0.027***	0.027***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	66	66	66	66	66
R^2	0.310	0.364	0.409	0.404	0.428
Adjusted R^2	0.299	0.344	0.391	0.385	0.410
F Statistic	28.776***	18.050***	21.823***	21.363***	23.583***

Note: bootstrapped standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

[44] In all cases, the number of lags is selected minimizing the Bayesian Information Criterion (BIC).

TABLE 10
FORECASTING MODEL FOR CHILE

Sample period is 2010.Q1-2019.Q1. Data frequency is quarterly. vol_embiarg: country risk volatility of Chile. fear_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "fear". uncertainty_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "uncertainty". pessimism_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "pessimism". combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted.

	(1)	(2)	(3)	(4)	(5)
vol_embich_t	0.002	0.002	0.002	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
fear_weighted_t		0.0001			
		(0.0006)			
pessimism_weighted_t			-0.0003		
			(0.0008)		
uncertainty_weighted_t				-0.0003	
				(0.0009)	
combined_indices_t					-0.0003
					(0.0008)
Constant	0.024***	0.024***	0.024***	0.024***	0.024***
	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
Observations	34	34	34	34	34
R^2	0.103	0.103	0.107	0.106	0.106
Adjusted R^2	0.075	0.045	0.05	0.048	0.049
F Statistic	3.672*	1.784	1.860	1.834	1.844

Note: nonparametric bootstrapped standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

TABLE 11
FORECASTING MODEL FOR PERU

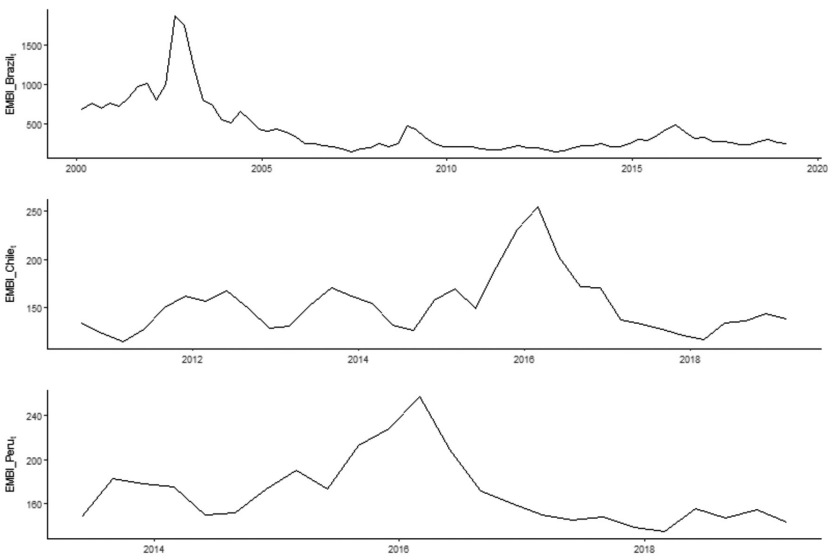
Sample period is 2013.Q1-2019.Q1. Data frequency is quarterly. vol_embiarg: country risk volatility of Peru. fear_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "fear". uncertainty_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "uncertainty". pessimism_weighted: is the average of the indices obtained using the 50, 500, and 1000 terms most strongly associated with "pessimism". combined_indices: average of indexes uncertainty_weighted, pessimism_weighted and fear_weighted.

	(1)	(2)	(3)	(4)	(5)
vol_embipe_t	0.001	0.001	0.001	0.001	0.001
	(0.0007)	(0.0009)	(0.0007)	(0.0007)	(0.0007)
fear_weighted_t		0.001			
		(0.0006)			
pessimism_weighted_t			0.001		
			(0.0007)		
uncertainty_weighted_t				0.0005	
				(0.0005)	
combined_indices_t					0.0006
					(0.0006)
Constant	0.027***	0.027***	0.027***	0.027***	0.027***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Observations	24	24	24	24	24
R^2	0.153	0.184	0.195	0.182	0.205
Adjusted R^2	0.114	0.108	0.119	0.104	0.130
F Statistic	3.971*	2.389	2.551	2.332	2.711

Note: nonparametric bootstrapped standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

These results are in line with the country risk variability of each country during the period analyzed (given by the availability of digital newspaper articles). Figure 6 shows the evolution of the country risk indicator for each country. The country spread of Brazil displayed a strong downward trend starting in the second quarter of 2002. By the end of the period, the Brazilian country risk oscillated around 500 basis points. In contrast, the country risk of Chile and Peru oscillates between 100 and 110 basis points during this period.

FIGURE 6
COUNTRY RISK OF BRAZIL, CHILE AND PERU



7. Conclusions

The unstructured information contents constitute a source of information that can help to understand the nature of certain economic phenomena. These new sources of information are potentially used by agents of the economy to formulate expectations and make decisions, which influence the dynamics of real economic and financial variables. Therefore, the study of links between indicators based on unstructured information and economic phenomena can shed light on our understanding of the nature of these phenomena.

This paper documents links between the dynamics of country risk volatility and several non-traditional indicators based on press content regarding the country risk topic. The estimated models provide a consistent picture of the association between these variables, that is, higher levels of manifestations of

subjective states -fear, uncertainty or pessimism- in articles regarding country risk topic are associated with a rise in the country risk volatility. Additionally, the evidence suggests that indices based on press media content have valuable information regarding future levels of country risk volatility. In particular, estimated forecasting models indicate that a one standard deviation increment in the indicator that captures manifestations of pessimism is associated to an increment of 0.21 standard deviations in next quarter expected country risk volatility of Argentina. The patterns documented in this work suggest that these non-traditional indicators allow for gains in forecast accuracy. These findings are robust to changes in the set of predictors, the specification of the model and the incorporation of new content published in the press. Also, the information provided by the non-traditional indicators is different from that provided by traditional macroeconomic indicators.

The patterns documented in this work suggest that there are gains associated with incorporating non-traditional sources of information in analyses that study the volatility of country risk. Taking into account the high influence that this variable exerts not only on the dynamics of the interest rate that emerging countries take debt, but also on the business cycle dynamics, we consider it relevant that resources are allocated towards a better understanding of these phenomena. This work shows that models that incorporate indicators that capture different manifestations of subjective states in the press articles describe more precisely the dynamics of country risk volatility.

There are several directions in which the exercises described above can be extended. In this sense, a possible direction is associated with the size of the sample. A higher sample will allow us to increase the precision level of the indicators. Another direction is related to the inclusion of variables that capture expectations of real and financial variables in the analysis. In this sense, several exercises could be estimated to evaluate whether these new variables display similar capacity to provide information regarding future levels country risk volatility. Finally, another possible direction is related to analyzing whether the patterns documented in this work keep when working with high frequency data.

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Appendix A

The LDA model assumes that the observed documents were generated through a probabilistic generative process. Therefore, the key inferential task of LDA is estimating the latent parameter structure of this generative process. LDA performs this task using the words of each document to estimate the parameters of the generative process that are most likely to have generated the collection of documents observed. Following Calvo-González *et al.* (2018), the generative process that LDA follows after specifying the number of topics k, is:

1. For each topic *k*, draw a distribution over the words φ_k according to a Dirichlet distribution ~ *Dir* (β), where β is a parameter that describes the prior knowledge about how the words are distributed in each topic.[45]
2. For each document *D*:
   a. Draw a vector of topic proportions θ_d according to a Dirichlet distribution ~ *Dir* (α), where α which describes the prior knowledge about how topics are distributed in documents.[46]
   b. For each word ω_n that belong to the vocabulary N:
      i. Draw a topic assignment Z_n according to a multinomial distribution ~Multinomial (θ), which depends on the topic proportion θ_d.
      ii. Given the topic, the most probable word ω_n is selected from the multinomial probability conditional distribution $p(\omega_n \mid Z_n, \varphi)$.

As we mentioned previously, the key inferential task of LDA consist in estimating the latent structure (the distribution of the parameters θ, Z and φ)[47] that are most likely to have generated the observed document.

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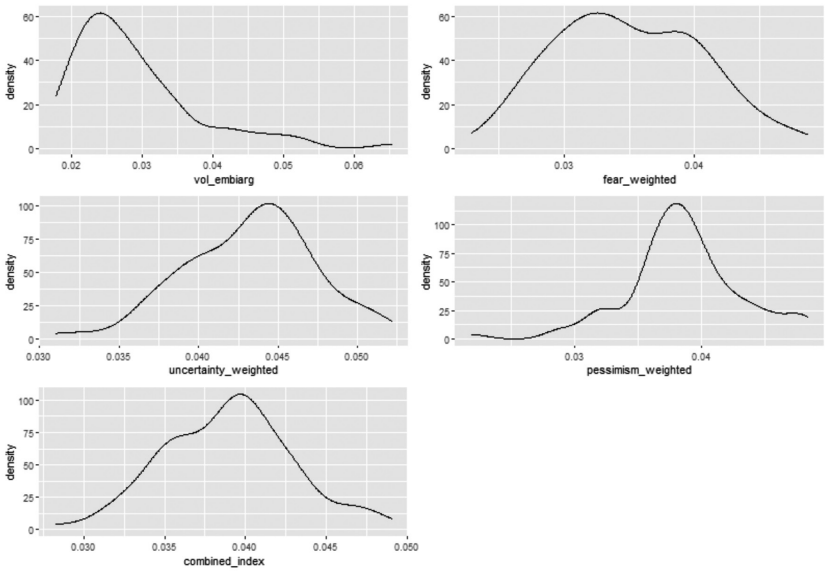
45 A high beta value means that each topic is likely to be made up of most of the words in the corpus, while a low beta indicates that each topic will have fewer words.

46 A high alpha means that each document is likely to contain a mixture of most of the topics, while a low alpha value means that each document is likely to contain fewer topics.

47 Where Z represents the per-word topic assignments, θ represents the proportion of topics per-document (that is, the topic distribution of each document), which indicates the extent to which each document belongs to each topic, and φ represents the distribution of words in topic k, which is used to define the semantic content of each topic.

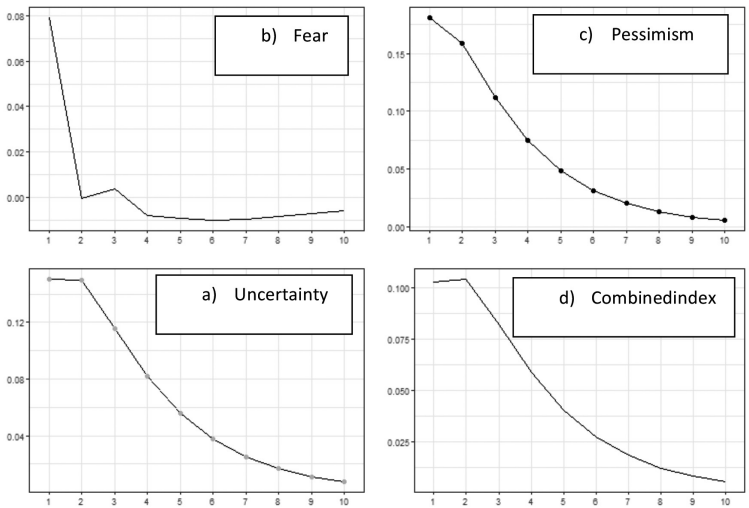
Appendix B

FIGURE B.1
ESTIMATED DENSITIES



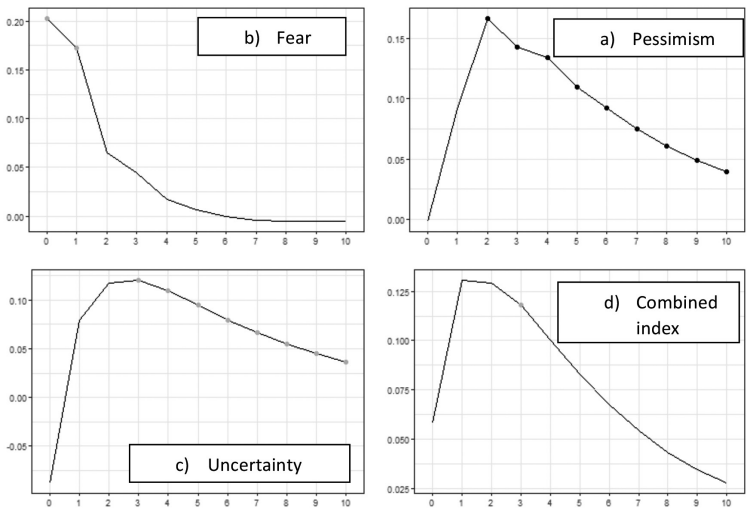
Appendix C

FIGURE C.1
RESPONSE TO NON-TRADITIONAL INDICATORS. DIFFERENT VAR LAGS



Note: Each graph shows responses to a positive shock of one standard deviation in non-traditional indicator. Black (gray) circles indicate statistical significance at 5 (10)%; solid line, no statistical significance.

FIGURE C.2
RESPONSE TO NON-TRADITIONAL INDICATORS. DIFFERENT VARIABLES ORDER



Note: Each graph shows responses to a positive shock of one standard deviation in non-traditional indicator Black (gray) circles indicate statistical significance at 5 (10)%; solid line, no statistical significance.

Empleo e inversión en actividades de innovación sin introducción de nuevas tecnologías: un estudio sobre Ecuador*

Employment and investment in innovation activities without introduction of new technologies: a study on Ecuador

Diego del Pozo**
Juan Fernández Sastre***

Resumen

Mediante el método de ponderación por probabilidad inversa y utilizando datos de la Encuesta Ecuatoriana de Innovación y del Instituto de Seguridad Social, este artículo estima el efecto de la introducción de tecnologías y de la inversión en actividades de innovación sin introducción de tecnologías en el empleo. Los resultados indican que solo la introducción de nuevas tecnologías incrementa el empleo en el corto plazo; aunque la inversión en I+D, sin introducción de tecnologías, aumenta la contratación de científicos. Finalmente, los resultados señalan que las empresas que introducen tecnologías incrementan la contratación de directivos, científicos y técnicos.

Palabras clave: *Empleo, I+D, otras actividades de innovación, pareo por propensión, países en desarrollo.*

Clasificación JEL: *O31, O32.*

Abstract

This article estimates the effect of the introduction of technologies and the effect of investing in innovation activities without the introduction of technologies on

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** Instituto Nacional de Estadística y Censos (INEC). E-mail: diegofdelpozov@gmail.com (D. Del Pozo).
*** Facultad Latinoamericana de Ciencias Sociales (FLACSO-ECUADOR). E-mail: jfernandez@flacso.edu.ec (J. Fernández-Sastre).
Correspondencia del autor: diegofdelpozov@gmail.com (D. Del Pozo).

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employment, using data from the Ecuadorian Innovation Survey and the Social Security Institute and applying the inverse probability weighting methodology. The results indicate that only the introduction of new technologies increases total employment in the short run; although investment in R&D, without the introduction of technologies, increases the recruitment of scientists. Finally, firms that introduce technologies increase the hiring of managers, scientists and technicians.

Key words: *Employment, R&D, other innovation activities, matching by propensity, developing countries.*

JEL Classification: *O31, O32.*

1. Introducción

El efecto de la innovación en el empleo de las empresas ha sido un tema ampliamente analizado en la literatura empírica. En función de cómo se mide la variable respecto de innovación, se pueden distinguir dos tipos de estudios: aquellos que analizan cómo la introducción de nuevos productos y procesos incide en el empleo (Harrison *et al.* 2008; Crespi y Tacsir 2011; López y Zárate 2014; Cirera y Sabetti 2016; Dachs *et al.* 2017) y aquellos que examinan la influencia de la inversión en actividades de innovación. No obstante, estos últimos no distinguen entre las empresas que introducen nuevas tecnologías y las empresas que, pese a invertir en innovación, no las introducen. Así, sus resultados están muy vinculados con la estimación del efecto de la introducción de nuevos productos y procesos. Por lo general, estos estudios señalan que la inversión en I+D, principalmente la orientada al desarrollo de nuevos productos, tiende a generar empleo (Van Reenen 1997; Greenhalgh, Longland y Bosworth 2001; Piva y Vivarelli 2017); mientras que la evidencia referida a efectos negativos es mucho más limitada (Brouwer, Kleinknecht y Reijnen 1993; Klette y Førre 1998).

Por su parte, los estudios que analizan el efecto de la introducción de nuevas tecnologías, en la mayoría de los casos, muestran efectos positivos de la innovación de productos y efectos contradictorios respecto de la innovación de procesos (Heijs, Arenas y Vergara 2019). Los nuevos productos tienden a generar empleo al expandir las fronteras comerciales y estimular el aumento de la demanda (Lucchese y Pianta 2012); mientras que los nuevos procesos pueden disminuirlo al aumentar la productividad del trabajo o incrementarlo, por medio de la reducción de costos y precios (Vivarelli 2012; Cirera y Sabetti 2016).

Aunque los estudios empíricos miden la innovación según sus resultados o sus insumos, ninguno analiza si el desarrollo de actividades de innovación, cuando no se acompaña de la introducción de nuevas tecnologías, afecta al empleo. Este es precisamente el objetivo y aporte del presente artículo; aunque también mostramos evidencia por el efecto de la introducción de nuevas tecnologías. En este sentido, aunque la inversión en actividades de innovación permite desarrollar

nuevos conocimientos y habilidades con los que competir en el mercado (Kim 2001; Dutrénit 2004), resulta razonable considerar que las empresas que no introducen nuevas tecnologías no vean afectado su nivel de empleo. Esto es así debido a que la mera inversión en actividades de innovación no permite mejoras en la productividad, mediante reducciones de costes o mayores volúmenes de ventas. Sin embargo, aunque la inversión en innovación no debería afectar al empleo, podría ocurrir que el hecho de invertir en actividades de innovación llevase a las empresas a incrementar la contratación de personal con formación científica y capacidades de gestión; ya que la puesta en marcha de actividades de innovación requiere de trabajadores con alto nivel de cualificación y de personal encargado de gestionar el proceso (Doms, Timothy y Troske 1997). En este sentido, la inversión en actividades de innovación podría incrementar la contratación de determinados tipos de ocupaciones que disponen de las habilidades necesarias para poder llevar a cabo el proceso. Por ello, además de estimar el efecto en la variación del empleo, analizamos el efecto de la variación en los siguientes tipos de ocupaciones: directivos y gerentes; profesionales científicos e intelectuales; técnicos y profesionales de nivel medio; y el resto de ocupaciones[1].

Adicionalmente, podría ocurrir que el efecto en la contratación de personal con alta cualificación dependa del tipo de actividades de innovación que desarrollan las empresas. En este artículo distinguimos entre dos tipos de actividades: "inversión en I+D sin introducción tecnológica" e "inversión en otras actividades de innovación sin introducción tecnológica". La inversión en otras actividades de innovación incluye inversiones para el desarrollo de nuevos productos o procesos en adquisición de maquinaria y equipo, *software*, *hardware*, tecnología desincorporada, consultorías, actividades de ingeniería y diseño industrial, capacitación del personal y estudios de mercado.

La delimitación del estudio es Ecuador, un país latinoamericano de ingreso medio caracterizado por un sistema de innovación emergente. Así, este artículo también contribuye a la evidencia empírica acerca de la relación entre innovación y empleo en un país en desarrollo, donde la mayoría de las empresas no se involucra en actividades formales de I+D. De acuerdo con la Encuesta Ecuatoriana de Innovación del 2015, el 43,3% de las empresas se puede considerar como innovadoras, al invertir en actividades de innovación o al haber introducido nuevas tecnologías en el mercado. De estas el 93,7% introdujo nuevos productos o procesos durante el periodo de la encuesta (2012-2014); mientras que el 6,3% invirtió en actividades de innovación, pero no introdujo nuevas tecnologías. Finalmente, de las empresas que no introdujeron nuevas tecnologías el 27,5% desarrolló proyectos de I+D; mientras que el 87,7% invirtió en otras actividades de innovación.

[1] "Resto de ocupaciones agrupa: empleados de oficina; trabajadores de servicios y comerciantes; oficiales, operarios y artesanos de artes mecánicas y otros oficios; operadores de instalaciones y máquinas ensambladores; trabajadores no cualificados.

Existe una creciente literatura empírica concerniente a innovación y empleo en países en desarrollo. La mayoría de los estudios se han centrado en analizar el impacto de la introducción de nuevos productos y procesos. Sus resultados muestran que la innovación de producto es fuente de generación de empleo; mientras que no hay evidencia de que la innovación de proceso desplace trabajadores (Álvarez *et al.* 2011; Aboal *et al.* 2015; López y Zárate 2014; Cirera y Sabetti 2016). Dos excepciones a los estudios respecto de resultados de la innovación son los trabajos de Crespi y Zuniga (2012) y Álvarez *et al.* (2011). Los primeros examinan el impacto de las estrategias de inversión en actividades de innovación "I+D interna", "I+D externa" e "I+D interna y externa" en el crecimiento del empleo de empresas de Argentina, Chile y Uruguay. Sus resultados indican que la "I+D interna" es la estrategia con mayor impacto positivo en el empleo y que la estrategia mixta es la segunda. Asimismo, evidencian que la innovación de productos se genera principalmente por "I+D interna" y la de procesos mediante "I+D externa". Esto vincula sus resultados con el efecto de la introducción de nuevas tecnologías en el empleo. Por su parte, los resultados de Álvarez *et al.* (2011), para el caso de empresas chilenas, indican que la "I+D interna" está asociada positivamente con el crecimiento del empleo, aunque no en el caso de las pequeñas empresas.

Finalmente, en el terreno metodológico, la mayoría de los estudios tienen en cuenta el problema de endogeneidad a la hora de estimar el efecto de la innovación en el empleo. Esto se produce porque la introducción de nuevas tecnologías o la inversión en actividades de innovación resultan correlacionadas con el término de error; es decir, con factores como *shocks* externos, precios diferentes de los nuevos productos u otros aspectos que influyen en el empleo (Harrison *et al.* 2008; 2014). Desde el seminal estudio de Harrison *et al.* (2008), la manera habitual de estimar el efecto causal ha sido por medio del uso de variables instrumentales y el uso de variables rezagadas como instrumentos cuando se dispone de paneles de datos (método GMM). En este artículo, debido a que la Encuesta Ecuatoriana de Innovación no es un panel de datos, recurrimos a la metodología de ponderación por probabilidad inversa, que es un método de emparejamiento basado en el puntaje por propensión, que son metodologías que también han sido utilizadas en otros estudios de innovación y empleo (Kim 2018).

El resto del artículo está organizado de la siguiente manera: la Sección 2 revisa la literatura de innovación y empleo y discute por el efecto de la inversión en actividades de innovación, sin introducción de nuevas tecnologías. La Sección 3 presenta los datos y la metodología. La Sección 4 discute las implicaciones de los resultados empíricos. Finalmente, concluimos en la Sección 5.

2. Revisión de literatura

Los estudios empíricos referidos a innovación y empleo se diferencian en función de si miden la innovación de sus insumos (inversión en actividades de innovación) o de sus resultados (introducción de nuevos productos y procesos)

(véase Heijs, Arenas y Vergara (2019) para una revisión de la literatura). No obstante, ambos tipos de estudios tratan de analizar el efecto de la introducción de nuevas tecnologías, ya que los primeros parten de la consideración de que hay una relación positiva entre la inversión en innovación y la introducción de nuevas tecnologías. Así, el efecto en el empleo no se justifica porque invertir en actividades de innovación estimule en sí la contratación de trabajadores, sino porque esta deriva en la introducción de nuevas tecnologías que acaban por afectar al empleo. De hecho, ante esta consideración, varios de los estudios distinguen entre la inversión en actividades de innovación orientada al desarrollo de nuevos productos y la orientada al desarrollo de nuevos procesos (Brouwer, Kleinknecht y Reijnen 1993; Barbieri, Piva y Vivarelli 2019; Piva y Vivarelli 2005).

Los estudios de insumos en la mayoría de los casos muestran un impacto positivo de la innovación, comúnmente medida como la inversión en I+D en relación con el número de empleados de la empresa (intensidad de la I+D). Por ejemplo, Greenhalgh, *et al.* (2001), en un panel de datos de empresas británicas, muestran que la intensidad de la I+D tiene un efecto positivo en la evolución del empleo, especialmente en los sectores de alta intensidad tecnológica. Bogliacino, Piva y Vivarelli (2014), para empresas europeas, encuentran que la inversión en I+D tiene un efecto positivo en el empleo, aunque solo detectable en las empresas de servicios y en las manufacturas de alta intensidad tecnológica. Piva y Vivarelli (2017) también confirman el efecto positivo de la inversión en I+D en una base de datos de empresas europeas. No obstante, sus resultados indican que el efecto no es significativo en los sectores de baja intensidad tecnológica. El hecho de que muchos estudios indiquen que la inversión en I+D produzca principalmente crecimiento en el empleo en empresas de sectores de alta intensidad tecnológica se explica porque, en estos sectores, la innovación se orienta principalmente al desarrollo de nuevos productos, lo que tiende a estar positivamente relacionado con el empleo. Yang y Lin (2008) también muestran un efecto positivo de la inversión en I+D (y del número de patentes) en el empleo de empresas taiwanesas. Kancs y Siliverstovs (2020) en un panel de datos de empresas de la OCDE también muestran un efecto positivo de la intensidad de la I+D. Además, sus resultados sugieren que el efecto es diferente en función del nivel de la intensidad de la I+D.

Otros estudios relacionados con insumos ponen en contradicho el efecto positivo de la inversión en I+D, incluso en los sectores de alta intensidad tecnológica. Klette y Førre (1998), en un panel de datos de empresas noruegas, hallaron que no hay una relación clara entre la intensidad de la I+D y la creación neta de empleo y que esta última no fue mayor en los sectores de alta intensidad tecnológica. Brouwer, *et al.* (1993), para empresas manufactureras holandesas, muestran que el crecimiento de la intensidad de la I+D tiene un ligero impacto negativo en el empleo. No obstante, sus resultados señalan que las empresas que direccionan su inversión al desarrollo de productos generaron empleo.

Debido a que el efecto de la inversión en actividades de innovación depende del tipo de innovaciones que introducen las empresas, algunos estudios de insumos han tratado de distinguir entre inversiones en distintos tipos de actividades, que

podrían estar más relacionadas con el desarrollo de nuevos productos o procesos. Por ejemplo, Barbieri, Piva y Vivarelli (2019), para empresas italianas, encuentran un efecto positivo del gasto en I+D (que se asume orientado al desarrollo de nuevos productos); mientras que el gasto en adquisición de maquinaria y equipo innovador (que se asume orientado a la introducción de nuevos procesos) muestra un efecto negativo. No obstante, como los autores señalan, el efecto atribuible a la innovación de productos y procesos normalmente está interrelacionado, porque muchas empresas invierten en ambos tipos de actividades e introducen simultáneamente ambas tecnologías. Además, el efecto negativo de la innovación de procesos puede ser compensado y la empresa puede acabar reabsorbiendo el desempleo generado por la misma. Piva y Vivarelli (2005) examinan el efecto de la inversión en actividades de innovación que no son I+D en empresas manufactureras italianas. Sus resultados indican la existencia de una relación positiva entre la inversión en otras actividades de innovación y el empleo, aunque el efecto resultó bastante modesto. Pellegrino, Piva y Vivarelli (2018) estiman el impacto en el empleo de distintos tipos de inversiones en actividades de innovación, en empresas manufactureras españolas. Sus resultados no muestran ni que la inversión en I+D o en maquinaria y equipo innovador tengan un impacto significativo en el empleo. No obstante, el efecto de la I+D es significativo y positivo en sectores de alta intensidad tecnológica.

La mayoría de los estudios de innovación y empleo, analiza el efecto de la introducción de nuevos productos y procesos. Por un lado, en lo que respecta a la introducción de nuevos productos, la inmensa mayoría de los estudios encuentran un impacto positivo (Heijs, Arenas y Vergara 2019). El resto de estudios muestran relaciones no significativas, normalmente en países en desarrollo y sectores de baja intensidad tecnológica (Dachs *et al.* 2017; Mastrostefano y Pianta 2009). Por otro lado, la mayoría de los estudios muestra efectos no significativos de los nuevos procesos (Meriküll 2010; Hou *et al.* 2019; Bianchini y Pellegrino 2019); aunque también hay evidencia de efectos positivos (Alonso-Borrego y Collado 2002) y aún más acerca de efectos negativos (Dachs *et al.* 2017; Heijs, Arenas, y Vergara 2019). En este sentido, resulta pertinente recordar que los nuevos procesos pueden generar pérdidas de trabajo debido a mayor productividad, que pueden ser compensadas mediante distintos mecanismos tales como menores costes, que se traducen en menores precios y una expansión de la demanda y ganancia de cuota de mercado respecto de la competencia (Heijs, Arena y Vergara 2019). Por ejemplo, Harrison *et al.* (2014), para empresas de España, Francia, Alemania y Reino Unido, encuentran que la innovación de procesos no reduce el número de trabajadores, ya que el crecimiento de la demanda de viejos productos compensa las pérdidas de empleo derivadas de la innovación de proceso. Además, sus resultados muestran un claro efecto positivo de la innovación de productos. Yang y Lin (2008) para empresas taiwanesas también encuentran efectos positivos de la innovación de producto y proceso; aunque el efecto de la innovación de proceso se da principalmente en sectores de alta intensidad tecnológica. Lachenmaier y Rottmann (2011), en empresas manufactureras alemanas, encuentran que tanto la innovación de productos como la de

procesos afecta positivamente al empleo y que ambas lo hacen con un retardo temporal; siendo mayor el retardo de la innovación de procesos.

Otros estudios han analizado la incidencia de la innovación en el tipo de ocupación y en el nivel de cualificación de los trabajadores (Doms, Timothy y Troske 1997; Acemoglu 2000; Addison, Fox y Ruhm 2000). La incorporación de nueva tecnología, normalmente, requiere de trabajadores con habilidades técnicas que optimicen la productividad y faciliten la adaptación tecnológica (Görg y Strobl, 2002). Arenas, Barge-Gil y Heijs (2020), en una muestra de empresas españolas durante un periodo de crisis económica, encuentran que tanto la innovación de producto como la de procesos influyó positivamente en el crecimiento del empleo y que la innovación de productos, especialmente, tiene un sesgo mayor hacia la demanda de trabajadores con mayor nivel de cualificación, en detrimento de trabajadores con baja cualificación.

En el caso de los estudios de empresas de países en desarrollo la mayoría de la evidencia estima el efecto de la introducción de nuevas tecnologías. En estos países y particularmente en el caso de los latinoamericanos, se tiende a encontrar efectos positivos de la innovación de productos y rara vez efectos negativos de la innovación de procesos (en muchos casos el efecto no resulta significativo). De acuerdo con Heijs, Arenas y Vergara (2019), una posible explicación a este resultado es que, en los países que están al comienzo de su proceso de industrialización, las empresas innovadoras tienden a crecer más y, por tanto, a compensar las pérdidas de empleo mediante mayores cuotas de mercado. Otros aspectos destacados en los estudios de innovación y empleo, en países latinoamericanos, es que factores como la rigidez de sus mercados de trabajo, la persistencia de pobreza y de un sector informal, estructuras productivas caracterizadas por pequeña y mediana empresa y sectores de baja intensidad tecnológica, en los que la innovación se orienta principalmente hacia la introducción de nuevos procesos y un proceso innovador que no se basa en la I+D, sino en rutinas de búsqueda y de aprendizaje entre tecnologías existentes, condicionan altamente el efecto que la innovación tiene para el empleo (Baldwin y Lin 2002; Baensch *et al.* 2019; Crespi, Tacsir y Pereira 2019). Además, estos países tienden a mostrar menores niveles de recursos humanos altamente calificados (Pereira y Tacsir 2019).

Para el caso de empresas colombianas, los resultados de Mejía y Arias (2014) y López y Zárate (2014) indican que las ventas derivadas de nuevos productos afectan positivamente al crecimiento del empleo; mientras que la innovación de procesos no muestra efectos de sustitución de trabajadores. Resultados similares fueron encontrados por Benavente y Lauterbach (2008) y Álvarez *et al.* (2011) para el caso de empresas chilenas y por De Elejalde, Giuliodori y Stucchi (2011) y Pereira y Tacsir (2019) para el caso de empresas argentinas. Para Uruguay, Aboal *et al.* (2015) encontraron un efecto positivo de la innovación de productos y un efecto negativo, aunque muy pequeño, de la innovación de procesos; especialmente en las empresas de alta intensidad tecnológica. Además, sus resultados indican que la innovación de productos tiene un efecto positivo principalmente en la contratación de trabajadores cualificados; mientras que la

de procesos desplaza trabajadores no cualificados y es neutral respecto de los cualificados. Baensch *et al.* (2019) en un estudio de 14 países latinoamericanos encontraron que la innovación de productos tiene un efecto positivo en el empleo y que la innovación de proceso no afecta a su crecimiento. Asimismo, sus resultados indican que los mercados laborales más rígidos reducen el efecto que la innovación tiene del empleo. Finalmente, Crespi, Tacsir y Pereira (2019), en un estudio de empresas de Argentina, Chile, Costa Rica y Uruguay, muestran que el crecimiento del empleo resulta positivamente afectado por ambos tipos de innovaciones y que los efectos de compensación son generalizados.

Como se introdujo, existen dos estudios respecto de innovación y empleo en países latinoamericanos que examinan el efecto de la inversión en actividades de innovación (Zuniga y Crespi 2013; Álvarez *et al.* 2011). Sus resultados sugieren que la inversión en I+D está positivamente relacionada con el crecimiento del empleo. Sin embargo, aunque esta inversión desarrolla la base de conocimientos, potencia las capacidades de gestión y hace que las empresas puedan explotar sus recursos más eficientemente, es posible esperar que, si no se materializa en una nueva tecnología, esta no tenga un efecto significativo en el crecimiento del empleo. La existencia de empresas que, pese a invertir en actividades para el desarrollo de nuevos productos y procesos, no los introducen se debe a tres factores: (i) el proyecto innovador aún está en curso; (ii) el proyecto innovador ha fracasado; y (iii) el proyecto tenía poca proximidad con el mercado y estaba relacionado con investigación básica. No obstante, independientemente de cuál fuere el motivo por el que la inversión en innovación no se materializó en la introducción de una nueva tecnología, resulta plausible considerar que esta no tenga un efecto significativo para el crecimiento del empleo. Es por ello que planteamos la siguiente hipótesis:

H1: La inversión en actividades de innovación, sin introducción de nuevas tecnologías, no afecta al crecimiento del empleo.

Además, también estamos interesados en analizar el efecto de la introducción de innovaciones en el crecimiento del empleo. En este sentido, como hemos visto, la evidencia para países en desarrollo es mayoritariamente a favor de un efecto positivo de la introducción de nuevas tecnologías en el empleo, debido a que las empresas innovadoras tienden a mostrar mejor desempeño y, por tanto, compensan las pérdidas de empleo con mayores cuotas de mercado (Heijs, Arenas y Vergara 2019). En consecuencia, se plantea la siguiente hipótesis:

H2: La introducción de nuevas tecnologías afecta positivamente al crecimiento del empleo[2].

[2] Nótese que en el Apéndice 1 se muestran los resultados del efecto de la introducción de tecnologías distinguiendo entre la introducción de "solo nuevos productos"; "solo nuevos procesos" y "nuevos productos y procesos". Por tanto, también presentamos evidencia en el impacto de la innovación en el empleo en función del tipo de tecnología.

Aunque es de esperar que la inversión en innovación, sin introducción de nuevas tecnologías, no influya en el crecimiento del empleo, el desarrollo de actividades de innovación normalmente requiere de la contratación de nuevo personal que apoye la mejora de los procesos y permita llevarlos a cabo de manera exitosa. Así, es posible que las empresas que invierten en innovación y no introducen nuevas tecnologías incrementen la contratación de personal cualificado con el objetivo de poder llevar a cabo los proyectos de innovación. Esto podría hacer que las empresas contraten personal con mayor nivel de instrucción y cualificación, que tenga las habilidades necesarias para comprender las nuevas tecnologías y los obstáculos que emergen durante el proceso innovador (Doms, Timothy, y Troske 1997). En este sentido, el estudio de Bello-Pintado y Bianchi (2019), de empresas uruguayas, muestra que las empresas que adoptan estrategias de innovación abierta demandan nuevos empleados con mayores habilidades técnicas y sociales. En consecuencia, planteamos la siguiente hipótesis:

H3: La inversión en actividades de innovación, sin introducción de nuevas tecnologías, aumenta la contratación de trabajadores cualificados.

Finalmente, el efecto en el crecimiento del empleo cualificado, de la inversión en actividades de innovación sin introducción tecnológica, podría variar en función del tipo de actividades de innovación en las que invierten las empresas. En particular podrían existir diferencias entre la inversión en I+D y la inversión en otras actividades de innovación. Las actividades de I+D están más relacionadas con la generación de nuevo conocimiento tecnológico y las empresas que se involucran en ellas requieren de altas capacidades para su ejecución (Doms, Timothy, y Troske 1997). Esto podría provocar un aumento de la demanda de mano de obra con alto nivel de cualificación. Por el contrario, las otras actividades de innovación, que principalmente hacen referencia a la adquisición de maquinaria y equipo para el desarrollo de nuevas tecnologías, no deberían estimular tanto la contratación de nuevos trabajadores, sino más bien la capacitación de los existentes. Esto es así, ya que estas actividades están relacionadas con la explotación del conocimiento tecnológico que ya existe en el mercado, en lugar de seguir con la generación de nuevo conocimiento (Barge-Gil, Nieto y Santamaría 2011). Por ello formulamos la siguiente hipótesis:

H4**:** La inversión en I+D, sin introducción de nuevas tecnologías, produce un mayor efecto en el crecimiento del empleo cualificado que la inversión en otras actividades de innovación.

3. Datos y metodología

El presente artículo utiliza datos de la Encuesta Nacional de Actividades de Innovación del Ecuador del año 2015 (ENAI 2015). La encuesta, que recoge

datos del periodo 2012-2014 para 6.275 empresas[3], fue levantada por el Instituto Nacional de Estadística y Censos y la Secretaría de Educación Superior, Ciencia, Tecnología e Innovación. La muestra se realizó para empresas con 10 o más empleados[4], pertenecientes a las ramas de actividad de manufactura, comercio, minería y servicios[5]. La encuesta, que sigue las directrices del Manual de Oslo (2006), realizó un muestreo probabilístico estratificado con asignación de Neyman y selección aleatoria, para ello tomó como variable de diseño las ventas totales de la empresa en el 2014. Adicionalmente, para obtener datos del empleo por tipo de ocupación, se fusionó la ENAI con los registros administrativos de afiliaciones del Instituto Ecuatoriano de Seguridad Social[6] para obtener la información correspondiente al empleo por tipo de ocupación (CIUO 08) para cada una de las empresas que conforman la ENAI.

Debido a que el objetivo principal es el de analizar si la inversión en actividades de innovación, sin introducción de nuevas tecnologías, afecta a la variación del empleo total y por tipo de ocupación, las variables dependientes reflejan la variación del empleo total y por tipo de ocupación durante el periodo de la encuesta. La variación del empleo total (*cto_empleo*) se mide como la diferencia del logaritmo natural de 1 más el empleo de la empresa en el 2014 y el logaritmo natural de 1 más el empleo de la empresa en el 2012. Respecto de la variación del empleo por tipo de ocupación, las distintas variables se miden igual que *cto_empleo*, pero diferencian entre las siguientes ocupaciones: directores y gerentes, científicos e intelectuales, técnicos y profesionales y resto de

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3 Se seleccionó una muestra de 7.055 empresas a base del marco de muestreo del DIEE-2014, pero efectivamente se levantaron 6.275 empresas, es decir, la encuesta obtuvo una cobertura del 88,9%.

4 La muestra final incluye algunas empresas con menos de 10 empleados. Hemos decidido no eliminar estas empresas; debido a que pudo deberse a un desfase entre la elaboración del marco muestral y el levantamiento de la información.

5 Para construir los dominios de estudio se agruparon las 14 ramas de actividad del CIIU 4 a 1 dígito (explotación de minas y canteras; industrias manufactureras; suministro de electricidad, gas, vapor y aire acondicionado; distribución de agua, alcantarillado, gestión de desechos y actividades de saneamiento; construcción; comercio al por mayor, reparación de vehículos, automotores y motocicletas; transporte y almacenamiento; actividades de alojamiento y servicio de comidas; información y comunicación; actividades financieras y de seguros; actividades inmobiliarias; actividades profesionales, científicas y técnicas; actividades de servicios administrativos y de apoyo; actividades de atención a la salud y asistencia social) en cuatro categorías: industrias manufactureras, explotación de minas y canteras, comercio y servicios (INEC 2016).

6 El emparejamiento entre la encuesta ENAI y la base de datos de afiliados del IESS se hizo a partir del código pseudonimizado correspondiente al Registro Único de Contribuyentes (RUC) del INEC que presentan ambas fuentes, lo que permitió una fusión total de las bases de datos. La base de datos de afiliados del IESS al ser una base de datos de *stock* contiene información para todos los meses de los años que conforman el periodo de referencia de la encuesta, es decir, 2012-2014 y es actualizada continuamente. Por este motivo, a lo largo de los meses que conforman el periodo de referencia se presentan fluctuaciones en las variables de empleo total, por lo que se ha considerado emparejar la encuesta ENAI con las variables de empleo total registrado desagregado por el tipo de ocupación (CIUO 08) desde mayo del 2012 al 2014, al ser mayo el mes de mayor estabilidad en dichas variables.

ocupaciones[7]. Para cada una de las categorías se generan sus correspondientes variables de resultado: *cto_directivos*, *cto_científicos*, *cto_tecnicos*, *cto_resto*. Nótese que con el objetivo de comprobar la hipótesis H4, consideremos que los trabajadores con mayor nivel de cualificación están representados por la categoría de *científicos,* que presumiblemente es la categoría más relacionada con el desarrollo de actividades de innovación.

Con el objetivo de comprobar las hipótesis H1 y H3, se genera la variable de tratamiento *inversor,* que es una variable dicotómica que toma valor 1 si la empresa invirtió en actividades de innovación (I+D u otras actividades de innovación) y no introdujo nuevos productos o procesos durante el periodo 2012-2014. Por su parte, el grupo control, que es el mismo para el resto de variables de tratamiento que describiremos a continuación, está constituido por empresas no innovadoras; es decir, por aquellas que no invirtieron en actividades de innovación y no introdujeron nuevas tecnologías durante el periodo 2012-2014. Adicionalmente, excluimos del grupo control 1.764 empresas que no invirtieron en actividades de innovación, ni introdujeron nuevas tecnologías debido a innovaciones introducidas en años anteriores[8]. Resulta adecuado no incluir a estas empresas en el grupo control, ya que, en realidad, son empresas innovadoras y es de esperar que tengan un comportamiento del empleo distinto al de las no innovadoras.

Para verificar la hipótesis H2, se genera la variable *introductor*, que es una variable dicotómica que toma valor 1 si la empresa introdujo nuevos productos o procesos durante el periodo 2012-2014. Adicionalmente, con la intención de ver si el efecto en el empleo es sensible al tipo de tecnología que introducen las empresas, el Apéndice 1 muestra los resultados de tres variables de tratamiento similares a *introductor*, pero que diferencian entre las empresas que introdujeron solo nuevos productos (*solo_producto*), las que introdujeron solo nuevos procesos (*solo_proceso*) y las que introdujeron ambos tipos de innovaciones (*producto_proceso*). Finalmente, para comprobar la hipótesis H4 se generarán dos variables de tratamiento. La primera variable *inversor_ID* toma valor 1 si la empresa invirtió en actividades de I+D y no introdujo nuevas tecnologías[9]. La segunda variable *inversor_no_ID* toma valor 1 si la empresa invirtió exclusivamente en otras actividades de innovación y no introdujo nuevas tecnologías. Además, debido a que resulta plausible considerar que las empresas que invierten en actividades de innovación y no introducen nuevas tecnologías puedan estar

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7 El resto de ocupaciones comprende personal de apoyo administrativo; trabajadores de los servicios y vendedores de comercios y mercados; agricultores y trabajadores calificados agropecuarios, forestales y pesqueros; oficiales, operarios y artesanos de artes mecánicas y de otros oficios; operadores de instalaciones y máquinas y ensambladores; no calificados.

8 ENAI en su sección X pide a las empresas que señalen en una escala de 4 valores (no experimentado, bajo, medio y alto) qué importante fue la razón para no innovar porque no hubo necesidad debido a innovaciones anteriormente introducidas por la empresa. Hemos eliminado del grupo control a toda empresa que señaló bajo, medio o alto en esta sección.

9 Nótese que estas empresas pueden haber invertido o no en otras actividades de innovación.

introduciendo innovaciones organizacionales[10], podría ocurrir que el efecto atribuido a las variables *inversor_ID* e *inversor_no_ID* resulte influido por la introducción de innovaciones organizacionales. Con la intención de aislar este efecto generamos las variables *inversor_ID_no_org* e *inversor_no_ID_no_org,* que toman valor 1 en la misma situación que las anteriores, pero además se exige que la empresa no haya introducido innovaciones organizacionales durante el periodo. El principal inconveniente de estas dos variables de tratamiento es que, al ser tan restrictivas, su número de observaciones es muy reducido, lo que afecta a la estimación de los errores estándar, por lo que sus resultados deben ser tomados con cautela. Pocos estudios han analizado el impacto de la innovación organizacional en el empleo y no existe una evidencia empírica concluyente. Heijs, Arenas y Vergara (2019) identifican 5 estudios que analizan el efecto de la innovación organizacional en 18 muestras diferentes: 4 mostraron efectos positivos; 8 no significativos y en 6 resultó negativa.

El Cuadro 1 muestra el número de observaciones para cada uno de los tratamientos.

CUADRO 1
VARIABLES DE TRATAMIENTO

Variable	1	0	Total
(T1) introductor	2.544	1.796	4.340
(T2) inversor	171	1.796	1.967
(T3) inversor_ID	47	1.796	1.843
(T4) inversor_no_ID	124	1.796	1.920
(T5) inversor_ID_no_org	31	1.796	1.827
(T6) inversor_no_ID_no_org	74	1.796	1.870

Sea $T \in [0,1]$, una de las variables de tratamiento del Cuadro 1 e Y una de las variables de resultado (*cto_empleo, cto_directivos, cto_cientificos, cto_tecnicos y cto_resto*) continua. La expresión (1) muestra el problema de estimación del efecto del tratamiento (*average tratment effect on the treated - ATT*), debido a la información de la que se dispone en los datos.

$$(1) \qquad ATT = E(Y_{1i} \mid T=1) - E(Y_{0i} \mid T=1)$$

Donde, Y_{1i} corresponde al crecimiento del empleo de la empresa *i* que realiza una de las estrategias de innovación del Cuadro 1 (T1–T6) e Y_{0i} corresponde al crecimiento del empleo de la misma empresa *i* si no hubiera realizado dicha

[10] La innovación organizacional contempla: (i) nuevas prácticas de negocio; (ii) nuevos métodos de organización de responsabilidades y de toma de decisiones; (iii) nuevos métodos de organización del relacionamiento externo con otras empresas o instituciones.

estrategia. Así, en la expresión (1) se puede ver problema de estimación del efecto causal, ya que no se puede observar directamente $E(Y_{0i}|T=1)$ al tratarse de un resultado potencial. De tal manera que, con la información disponible solo se puede calcular el efecto del tratamiento por medio de la diferencia de medias entre tratados y no tratados, es decir $E(Y_{1i}|T=1)-E(Y_{0i}\mid T=0)$, siempre que el tratamiento *T* haya sido distribuido aleatoriamente entre las empresas. Esto es así, ya que la aleatorización garantiza que las diferencias en las características de las empresas tratadas y no tratadas (diferentes *shocks*, diferentes precios de los nuevos productos, etc.) no difieran en ausencia del tratamiento *T*, es decir $E(Y_{0i}\mid T=0)=E(Y_{0i}|T=1)$. Sin embargo, a causa de que los tratamientos no se encuentran sujetos a una asignación aleatoria, sino a una decisión de cada empresa, vinculada a ciertas características individuales que podrían incidir respecto de su empleo, surge la necesidad de generar un grupo de control comparable.

Para la estimación del efecto causal (ATT), este artículo utiliza la metodología propuesta por Hirano, Imbens y Ridder (2003) de ponderación por probabilidad inversa (*inverse probability weighting - IPW*), que calcula el ATT mediante la expresión:

$$\text{ATT}= E\,(Y_{1i}\mid T=1) - E\,(Y_{0i}\,p(x)/(1-p(x))\mid T=0) \tag{2}$$

Como se puede observar en la expresión (2), el grupo control se genera ponderando a las empresas no tratadas por el inverso del puntaje por propensión (*propensity score*) p(x), que es la probabilidad de recibir tratamiento; es decir, la probabilidad de que una empresa realice una determinada estrategia de innovación, condicionado a un vector de covariables observables medidas previas al tratamiento. No obstante, para la adecuada estimación del ATT, en la expresión (2) se requiere del cumplimiento de dos supuestos:

Supuesto 1. *Independencia de media condicional*: para un conjunto de covariables observables X que no son afectadas por el tratamiento, los resultados potenciales Y son independientes de la asignación T, lo que implica:

$$T \perp (Y_{0i}, Y_{1i}) \mid p(x) \tag{3}$$

Supuesto 2. *Soporte común*: cada empresa dentro del grupo de tratamiento debe tener empresas de comparación cercanas en la distribución del puntaje de propensión, lo que se nota como:

$$0< P\,(T=1 \mid X = x) < 1) \tag{4}$$

$$P\,(T = 1|X = x) < 1 \tag{5}$$

Por tanto, la metodología comienza con la estimación del puntaje por propensión ($p(X)$) a partir de un modelo *probit*, para posteriormente ponderar a las empresas del grupo control por el inverso del puntaje por propensión y calcular el efecto causal por medio de la expresión (2). Para el cálculo del puntaje por

propensión se deben incluir suficientes variables pretratamiento correlacionadas tanto con el tratamiento *T* como con la variable de resultado *Y;* así como el nivel de empleo en el año base 2012 (Fernández-Sastre y Montalvo-Quizhpi 2019). El Cuadro 2 describe todas las variables para el cálculo del puntaje por propensión, que están todas medidas en el año 2012. Nótese que debido a la importancia de incluir el nivel de empleo en año base, como control en el modelo *probit*, las variables *Empleo, Directivos, Científicos, Técnicos y Resto de ocupaciones*, que se describen en el Cuadro 2, no se incluyen en todos los modelos, sino que cada una se utiliza para el cálculo del puntaje por propensión, en función de la variable de resultado a analizar.

CUADRO 2
VARIABLES PARA EL CÁLCULO DE LOS PUNTAJES POR PROPENSIÓN

Variable	Descripción
ln_empleo12	Logaritmo natural del empleo total en el periodo inicial 2012
ln_directivos12	Logaritmo natural del número de directores y gerentes en el periodo inicial 2012
ln_científicos12	Logaritmo natural del número de profesionales, científicos e intelectuales en el periodo inicial 2012
ln_tecnicos12	Logaritmo natural del número de técnicos de nivel medio en el periodo inicial 2012
ln_resto12	Logaritmo natural del número de trabajadores del resto de ocupaciones en el periodo inicial 2012
ln_ventas12	Logaritmo natural de las ventas en el periodo inicial 2012
Exportadora	Variable dicotómica que toma 1 si la empresa exportó en el año 2012 y 0 en caso contrario
Creada	Variable dicotómica que toma 1 si la empresa fue creada en el periodo 2012 - 2014 y 0 en caso contrario
Extranjera	Variable dicotómica que toma 1 si la empresa forma parte de un grupo empresarial, cuya casa matriz no está localizada en Ecuador y 0 en caso contrario
Inversión en capital fijo	Variable dicotómica que toma el valor de 1 si invirtió en capital fijo en el 2012 y 0 en caso contrario
Sector	Se incluyen 4 variables dicotómicas sectoriales, de acuerdo con el CIIU a 1 dígito: (1) Minas y canteras; (2) Manufactura; (3) Servicios; (4) Comercio
Provincia*	Variable dicotómica que toma el valor de 1 si la empresa está establecida en Guayas o Pichincha y 0 caso contrario

Nota: *Se consideró a Guayas y Pichincha por ser las regiones de mayor valor agregado bruto per cápita del Ecuador.

El Cuadro 3 muestra la estimación del puntaje por propensión para cada uno de los tratamientos[11] para la variable de resultado *cto_empleo*, que muestra la variación total del empleo[12].

CUADRO 3
MODELO *PROBIT* - PUNTAJE DE PROPENSIÓN - PARA CRECIMIENTO DEL EMPLEO
(*cto_empleo*)

Variables	(T1)	(T2)	(T3)	(T4)	(T5)	(T6)
	introductor	inversor	inversor_ ID	inversor_ no_ID	inversor_ ID_no_ org	inversor_ no_ID_ no_org
ln_empleo12	–0,00264	0,104**	–0,142	0,105**	–0,232	0,0935
	(0,0750)	(0,0432)	(0,185)	(0,0478)	(0,203)	(0,0586)
Exportadora	0,0446	–0,119	0,409	–0,121	0,819	0,0139
	(0,609)	(0,137)	(1,247)	(0,153)	(1,485)	(0,171)
ln_ventas12	–0,0247	–0,00411	–0,0890	–0,0150	–0,0511	–0,0343
	(0,0271)	(0,0265)	(0,0649)	(0,0284)	(0,0716)	(0,0332)
Creada	–0,0909	0,190	–0,674*	0,141	–0,707*	0,0888
	(0,104)	(0,411)	(0,368)	(0,442)	(0,390)	(0,489)
Extranjera	0,194**	0,175	–0,179	0,226		0,256
	(0,0916)	(0,166)	(0,329)	(0,173)		(0,200)
Inversión en capital fijo	–0,916***	–0,509***	–0,0768	–0,647***	–0,208	–0,687***
	(0,0423)	(0,0847)	(0,138)	(0,0959)	(0,157)	(0,116)
Manufactura	0,531***	0,111	0,0129	0,180	0,426	0,321
	(0,120)	(0,224)	(0,294)	(0,266)	(0,372)	(0,339)
Servicios	0,151	–0,139	–0,405	0,0452	–0,0214	0,141
	(0,117)	(0,217)	(0,286)	(0,257)	(0,371)	(0,331)
Comercio	–0,175	–0,0241	–0,317	0,135	0,0460	0,118
	(0,120)	(0,217)	(0,296)	(0,261)	(0,379)	(0,337)
Provincia	–0,0563	0,170*	–0,314**	0,375***	–0,218	0,519***
	(0,0455)	(0,0952)	(0,149)	(0,110)	(0,161)	(0,137)
ln_ventas_Exportadora	–0,00521		–0,0309		–0,0600	
	(0,0381)		(0,0799)		(0,0967)	
ln_ventas_2	0,000156		0,00566*		0,00240	
	(0,00130)		(0,00323)		(0,00380)	
ln_empleo12_2	0,0148		0,0226		0,0317	
	(0,00957)		(0,0251)		(0,0281)	
ln_ventas12#Creada		–0,0278		–0,0109		–0,0172
		(0,0338)		(0,0352)		(0,0405)
Constante	0,682***	–1,414***	–1,212**	–1,644***	–1,379**	–1,738***
	(0,173)	(0,385)	(0,502)	(0,393)	(0,639)	(0,470)
Observaciones	4,340	1,967	1,843	1,920	1,827	1,870

Nota: Los modelos incluyen variables al cuadrado y distintas interacciones entre covariables.
Errores estándar robustos entre paréntesis.
La significancia está representada por: *** p<0,01; ** p<0,05; * p<0,1.

11 Se incluyeron interacciones entre variables en la estimación del modelo *probit*.

12 Los resultados de los modelos utilizados para el cálculo de los puntajes por propensión para la estimación de los efectos en el empleo por tipo de ocupación se encuentran bajo pedido al autor correspondiente.

Los resultados de la columna T1 muestran que las empresas que introducen nuevas tecnologías, en comparación con las empresas no innovadoras, son más propensas a ser empresas extranjeras y pertenecer a sectores manufactureros. Además, estas empresas fueron menos propensas a invertir en capital fijo. La columna T2 muestra que, en 2012, las empresas que invirtieron en actividades de innovación, pero que no introdujeron nuevas tecnologías, tenían un mayor número de empleados, fueron menos propensas a invertir en capital fijo y más propensas a estar localizadas en las provincias de mayor renta per cápita del país (Pichincha y Guayas); en comparación con las empresas que ni siquiera invirtieron en innovación. La columna T3 muestra que, en comparación con las empresas no innovadoras, las empresas que invirtieron en I+D y no introdujeron nuevas tecnologías, eran menos propensas a ser empresas de nueva creación y a estar localizadas en Pichincha o Guayas. La columna T4 señala que, en comparación con las empresas no innovadoras, las empresas que invirtieron en otras actividades de innovación y no introdujeron nuevas tecnologías eran de mayor tamaño, fueron menos propensas a invertir en capital fijo y más propensas a estar localizadas en Pichincha o Guayas. La columna T5 indica que, en comparación con las no innovadoras, las empresas que invirtieron en I+D, no introdujeron tecnologías y que, además, no introdujeron innovaciones organizacionales fueron menos propensas a ser empresas de nueva creación. Finalmente, la columna T6 señala que las empresas que invirtieron solo en otras actividades, no introdujeron nuevas tecnologías, ni innovaciones organizacionales fueron menos propensas a invertir en capital fijo y más propensas a estar localizadas en Pichincha o Guayas.

Una vez estimados los puntajes por propensión y previo a la estimación del ATT, mediante la expresión (2), es necesario verificar los supuestos en los que se basa el método. El cumplimiento del supuesto de independencia de media condicional no puede evaluarse de forma directa, ya que requiere de balance tanto en observables como no observables. Sin embargo, su plausibilidad puede analizarse mediante una prueba de balance de covariables observables después de la ponderación (Fernández-Sastre y Montalvo-Quizhpi 2019). El Cuadro 4 muestra la diferencia de medias y *ratio* de varianzas para cada una de las covariables, entre tratados y no tratados para el tratamiento *no_introductor* y la variable de resultado *cto_empleo*[13].

Los resultados del Cuadro 4 muestran que, tras la ponderación, las diferencias de medias en las covariables son prácticamente cero y que las *ratios* de varianza están muy próximas a uno; lo que denota que las covariables se encuentran balanceadas una vez aplicada la ponderación.

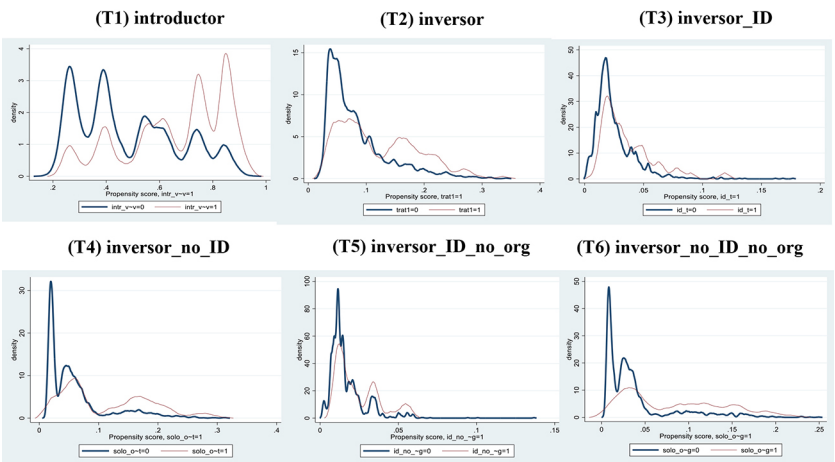
Para el cumplimiento del supuesto de superposición, es necesario que exista superposición en las densidades de la probabilidad de realizar una estrategia de innovación, entre las empresas del grupo de tratamiento y del grupo control. El Gráfico 1 muestra las densidades de los puntajes por propensión para los

[13] Las pruebas para el resto de variables de tratamiento y variables de resultado se encuentran bajo pedido al autor correspondiente.

CUADRO 4
BALANCE DE COVARIADAS: INTRODUCTOR (T1) – CRECIMIENTO DEL EMPLEO
(*cto_empleo*)

Covariada	Diferencias estándar		Proporción en varianza	
	Primario	Ponderado	Primario	Ponderado
ln_empleo12	0,364	0,005	1,258	1,015
Exportadora	0,130	0,025	1,348	1,053
ln_ventas12	0,172	0,013	0,725	1,028
Creada	–0,097	–0,011	0,695	0,955
Extranjera	0,084	0,004	1,346	1,013
Inversión en capital fijo	–0,797	–0,002	1,089	0,999
Manufactura	0,401	0,016	1,538	1,010
Servicios	0,032	0,000	1,013	1,000
Comercio	–0,408	–0,015	0,689	0,979
Provincia	0,021	–0,013	0,999	1,001
ln_ventas#Exportadora	0,143	0,028	1,446	1,073
ln_ventas12_2	0,178	0,020	0,928	1,061
ln_empleo12_2	0,369	0,008	1,775	1,027

GRÁFICO 1
SUPERPOSICIÓN POR TRATAMIENTO Y VARIABLE
DE RESULTADO CRECIMIENTO DEL EMPLEO
(*cto_empleo*)



distintos tratamientos en la estimación del efecto en la variable de resultado *cto_empleo*. Como se puede observar, la mayor parte de las densidades se superponen una con otra y no se concentra ni en el cero ni en el uno; por lo que no existe violación del supuesto[14].

4. Resultados

El Cuadro 5 muestra los ATT de los seis tratamientos, tanto para el crecimiento del empleo total como para el crecimiento de los distintos tipos de ocupación.

CUADRO 5
ATT DE LOS DIFERENTES TRATAMIENTOS EN EL CRECIMIENTO DEL EMPLEO
(*cto_empleo*)

ATT					
T_i	(1) *cto_ empleo*	(2) *cto_ directivos*	(3) *cto_ cientificos*	(4) *cto_ tecnicos*	(5) *cto_resto*
(T1) introductor	0,077***	0,063***	0,123***	0,048*	0,044
	(0,023)	(0,020)	(0,026)	(0,029)	(0,033)
(T2) inversor	0,043	0,024	0,125**	0,004	0,007
	(0,051)	(0,041)	(0,052)	(0,063)	(0,067)
(T3) inversor_ID	0,132*	0,134***	0,228***	0,002	0,098
	(0,079)	(0,054)	(0,082)	(0,096)	(0,093)
(T4) inversor_no_ID	-0,007	-0,030	0,074	0,005	-0,032
	(0,058)	(0,051)	(0,061)	(0,076)	(0,091)
(T5) inversor_ID_no_org	0,112	0,077	0,236***	-0,135	0,146
	(0,109)	(0,068)	(0,099)	(0,111)	(0,116)
(T6) inversor_no_ID_no_org	-0,038	-0,082	0,112	-0,087	-0,012
	(0,087)	(0,070)	(0,082)	(0,096)	(0,131)

Nota: Los errores estándar se encuentran entre paréntesis.
La significancia está representada por: *** p<0,01; ** p<0,05; * p<0,1.

Así como se puede observar en la primera columna, solo la introducción de nuevas tecnologías (*introductor*) produce un efecto significativo y positivo en el crecimiento de empleo. La inversión en actividades de innovación, sin introducción de nuevas tecnologías (*inversor*), sin embargo, no afecta al crecimiento del empleo. Estos resultados confirman las hipótesis H1 y H2; por lo que sugieren que el desarrollo de actividades de innovación, sin introducción de tecnologías,

[14] Los gráficos de superposición para el resto de variables de resultado se encuentran bajo pedido al autor correspondiente.

no fomenta lo suficiente el aprendizaje organizacional ni desarrolla nuevas habilidades con las que competir en el mercado, como para que las empresas alteren sus niveles de empleo, a menos en el corto plazo. En consecuencia, los resultados señalan que, si la inversión en actividades de innovación no viene acompañada de la introducción de una nueva tecnología, esta no produce un cambio en la empresa, como para afectar a la evolución de su empleo.

Asimismo, el efecto positivo de la introducción de nuevas tecnologías está en línea con otros estudios de países en desarrollo que tienden a mostrar que las empresas innovadoras son las que más empleo generan, presumiblemente gracias a que consiguen mayores cuotas de mercado (Heijs, Arenas y Vergara 2019). El inconveniente de la variable *introductor* es que no diferencia la introducción de innovaciones de producto o proceso. Por ello, el Apéndice 1 muestra los resultados para los tratamientos *solo_producto, solo_proceso* y *producto_proceso.* Los resultados indican que solo la introducción simultánea de nuevos productos y procesos tiene un impacto significativo en el crecimiento del empleo. Esto sugiere que para que la innovación tenga un impacto positivo, esta requiere ser lo suficientemente novedosa, en el sentido de que el nuevo producto requiera también de un nuevo proceso productivo. La introducción de un nuevo producto, sin innovaciones de proceso, no logra estimular la demanda lo suficiente como para que las empresas requieran incrementar su empleo, al menos durante el periodo analizado. Por su parte las empresas que no alteran su producto, pero que cambian su proceso productivo, no incrementan ni disminuyen su empleo; lo que sugiere una cierta compensación de las innovaciones de proceso en el empleo.

Los resultados de la primera columna, para el crecimiento total del empleo, también muestran un efecto positivo, aunque solo significativo al 90%[15] del tratamiento *inversor_ID*. Esto parecería indicar que la inversión en I+D, sin introducción de nuevas tecnologías, proporciona ventajas competitivas a las empresas, que mejoran su desempeño e incrementan sus niveles de empleo. Sin embargo, si atendemos a los resultados de la variable *inversor_ID_no_org*, que excluye la introducción de innovaciones organizacionales, vemos que este tratamiento ya no tiene un efecto significativo en la variación del empleo. Esto sugiere que el efecto positivo de la inversión en I+D respecto del crecimiento del empleo que observábamos antes, podría estar influenciado por no haber controlado por la introducción de innovaciones organizacionales. Finalmente, la columna 1 muestra que la inversión en otras actividades de innovación sin introducción de nuevas tecnologías (*inversor_no_ID*) no produce un efecto significativo en el crecimiento del empleo, independientemente de que excluyamos la introducción de innovaciones organizacionales del tratamiento. En definitiva, nuestros resultados vuelven a confirmar la hipótesis H1.

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15 Nótese además que, debido a que en Ecuador pocas empresas invierten en I+D, el tratamiento *inversor_ID* solo tiene 47 observaciones en el grupo de tratamiento, por lo que este resultado debe ser tomado con cautela.

Con respecto al crecimiento del empleo por tipo de ocupación (columnas 2-5), los resultados indican que, con la excepción de los tratamientos *inversor_no_ID* e *inversor_no_ID_no_org,* el resto produce un efecto positivo en el crecimiento de científicos e intelectuales (columna 3: *cto_cientificos*). De tal manera que la introducción de nuevas tecnologías y la inversión en I+D sin introducción de nuevas tecnologías incrementan la contratación de este tipo de trabajadores. Por tanto, se confirma la hipótesis H4, que planteaba que la inversión en I+D, sin introducción de nuevas tecnologías, produce un mayor efecto en el crecimiento del empleo cualificado que la inversión en otras actividades de innovación. De hecho, los resultados indican que la inversión solo en otras actividades de innovación, sin introducción de nuevas tecnologías, no afecta al crecimiento de ninguno de los tipos de ocupaciones. Así, los resultados señalan que, a diferencia de la inversión en I+D, la inversión en otras actividades de innovación, cuando no se acompaña de la introducción de nuevas tecnologías, no estimula la contratación de personal cualificado. Una posible explicación a este resultado es que la I+D requiere de la contratación de nuevos trabajadores con las habilidades técnicas necesarias para facilitar el aprendizaje tecnológico y poder llevar a cabo el proceso (Doms, Timothy y Troske 1997); mientras que las otras actividades de innovación, al fundamentarse en la adquisición de maquinaria y equipo innovador y en la explotación del conocimiento tecnológico existente, no requieren de nuevos trabajadores con la capacidad de generar nuevo conocimiento. Nótese, además, que el efecto significativo de la inversión en I+D, sin introducción de tecnologías, permanece cuando también excluimos la innovación organizacional y su ATT es muy similar (tratamiento *inversor_ID_no_org*).

Los resultados también indican que la introducción de nuevas tecnologías tiene un efecto positivo en el crecimiento de todas las categorías de empleados salvo en la categoría que agrupa al resto de ocupaciones. Este resultado sugiere que la innovación tiene un sesgo favorable hacia la contratación de científicos, directivos y técnicos; es decir, hacia trabajadores con mayor nivel de cualificación. Sin embargo, la inversión en innovación sin introducción de tecnologías solo incrementa la contratación de científicos, resultado que, en realidad, es exclusivo para las empresas que desarrollan proyectos de I+D. La columna 3 muestra que la inversión en I+D, sin introducción de nuevas tecnologías (*inversor_ID*), produce un efecto positivo en el crecimiento de directivos y gerentes. Aunque este resultado podría indicar que las empresas que invierten en I+D necesitan de directivos para construir las estrategias, estructuras y procesos que faciliten la ejecución de los diferentes tipos de innovación (Li, Li y Xie 2020); debemos dudar de este resultado, ya que el tratamiento que excluye la innovación organizacional (*inversor_ID_no_org*) no produce un efecto significativo en la categoría de directivos y gerentes. Esto sugiere que el efecto positivo de la inversión en I+D, sin introducción de tecnologías, respecto de esta ocupación, podría estar influenciado por la introducción de innovaciones organizaciones. De hecho, hay evidencia que muestra que la introducción de innovaciones organizacionales tiende a incrementar los puestos relacionados con la dirección y la gestión (Pianta 2005).

Finalmente, los resultados del Apéndice 1 muestran que, independientemente del tipo de tecnología introducida, siempre existe un efecto positivo en la contratación de científicos. Además, la introducción simultánea de productos y procesos tiene un impacto positivo respecto de la contratación de directivos y técnicos; y la introducción solo de innovaciones de proceso muestra un impacto positivo acerca del crecimiento de técnicos.

5. Conclusiones

Los estudios empíricos por el efecto de la innovación en el empleo son abundantes, y tanto para países desarrollados como en desarrollo en su mayoría examinan el efecto de la introducción de nuevos productos y procesos (Harrison *et al.* 2008; Crespi y Tacsir 2011; López y Zárate 2014; Cirera y Sabetti 2016; Dachs *et al.* 2017). Existen, también, algunos estudios que analizan el efecto de la inversión en actividades de innovación (Van Reenen 1997; Greenhalgh, Longland y Bosworth 2001; Piva y Vivarelli 2017; Álvarez *et al.* 2011; Crespi y Zuniga 2012), pero ninguno de ellos distingue entre las empresas que, pese a invertir en innovación, no introducen nuevas tecnologías. En consecuencia, no existe evidencia que corrobore si la inversión en actividades de innovación sin introducción de nuevas tecnologías influye en el empleo. Este artículo pretende llenar este vacío en la literatura, al estimar el efecto de la inversión en I+D y en otras actividades de innovación, sin introducción de nuevas tecnologías, en el crecimiento del empleo total y por tipo de ocupación. Adicionalmente, se muestra evidencia del efecto de la introducción de nuevas tecnologías. Para ello, utilizamos datos de la Encuesta Ecuatoriana de Innovación del 2015; por lo que este trabajo también contribuye a la creciente literatura empírica de innovación y empleo en países en desarrollo.

El artículo parte de la consideración de que la inversión en actividades de innovación, sin introducción de nuevas tecnologías, no influye en el crecimiento del empleo al no afectar a la productividad de la empresa; pero que es posible que estas empresas incrementen la contratación de personal cualificado para poder llevar a cabo el proyecto; especialmente si este involucra el desarrollo de actividades de I+D. Para la estimación del efecto causal, se recurre a la metodología ponderación por probabilidad inversa IPW (Hirano, Imbens y Ridder 2003); donde las empresas que invierten en actividades de innovación, sin introducir nuevas tecnologías, constituyen el grupo de tratamiento y el grupo control se genera ponderando a las empresas no innovadoras por la probabilidad inversa de recibir el tratamiento. Además, estimamos el efecto de otros tratamientos que diferencian otros comportamientos innovadores de las empresas.

Los resultados sugieren que mientras la introducción de nuevas tecnologías influye positivamente en el crecimiento del empleo, la inversión en actividades de innovación, sin introducción de nuevas tecnologías, no afecta al crecimiento del empleo de las empresas. No obstante, *ceteris paribus,* las empresas que no introdujeron tecnologías, pero que invirtieron en I+D incrementaron la contratación

de científicos. Finalmente, los resultados señalan que la introducción de nuevas tecnologías afecta al crecimiento del empleo en el corto plazo solo cuando se introducen simultáneamente nuevos productos y procesos. Además, señalan que las empresas que introducen solo nuevos productos incrementan la contratación de científicos y las que introducen solo nuevos procesos la de científicos y técnicos. Por su parte, la introducción simultánea de nuevos productos y procesos también muestra un efecto positivo en el crecimiento de directivos y gerentes.

No obstante, nuestros resultados se enfrentan a serias limitaciones, que hacen que deban ser tomados con cautela. En primer lugar, nuestros datos presentan amplias restricciones: la encuesta solo es representativa para empresas con 10 o más empleados, no se incluyen empresas del sector informal de la economía y no contiene información de muchos aspectos que pueden influir tanto en el empleo de las empresas como en su comportamiento innovador. Además, el hecho de que sea un corte transversal dificulta que nuestros resultados puedan ser interpretados en términos de causalidad. Hay que tener en cuenta que esto solo puede hacerse bajo el supuesto de que las empresas incluidas en el grupo de tratamiento y de control son iguales en aquellos factores que influyen en el empleo de los que no tenemos información en nuestra base de datos, algo que resulta improbable. Asimismo, los efectos de la innovación en el empleo pueden producirse con rezagos o diferir en el tiempo y nuestro análisis solo contempla la variación del empleo en un periodo de tres años; por lo que nuestros resultados aplican exclusivamente para el corto plazo. Esto, por ejemplo, podría influir mucho en el efecto positivo, que observamos, de la inversión en I+D sin introducción de tecnologías en la contratación de científicos. De manera similar podría ocurrir con el hecho de que la introducción solo de innovaciones de producto o solo de proceso no muestren un efecto significativo en el crecimiento del empleo. Finalmente, como resultado de analizar un país en desarrollo, algunas de nuestras variables de tratamiento contaban con pocas observaciones tratadas; lo que hace que desconfiemos de los errores estándar estimados. Por todo ello, queremos ser extremadamente cautos con nuestras conclusiones y en las recomendaciones de política económica que a continuación esbozamos.

Nuestros resultados parecen sugerir que para que la innovación tenga un efecto positivo, en el corto plazo, en el crecimiento del empleo de las empresas del Ecuador, esta debe materializarse en la introducción simultánea de un nuevo producto y proceso. De tal manera que, si se persigue fomentar el empleo mediante políticas de innovación, resultaría adecuado que se tratase de apoyar proyectos de innovación lo suficientemente sofisticados, que no solo alteren el producto que produce la empresa sino también la manera en la que lo produce. Los resultados sugieren que, al menos en el corto plazo, el hecho de ayudar a las empresas a que introduzcan solo nuevos productos no va a afectar a su empleo. También indican que la introducción solo de innovaciones de proceso no destruye empleo en el corto plazo; por lo que, *a priori*, resultarían recomendables aquellas políticas que fomenten la introducción de nuevos procesos en lo que a generación de empleo a nivel de empresa se refiere. No obstante, resulta pertinente mencionar que, así como indican Baensch *et al.* (2019), los efectos

de la innovación en el empleo dependen del contexto institucional y de las características del mercado laboral en particular. Por tanto, debido a que nuestro análisis es a corto plazo, es posible que este resultado esté influenciado por las características del mercado de trabajo ecuatoriano, que no es especialmente flexible. En este sentido, resulta importante señalar la pertinencia de coordinar las políticas de innovación con otros cambios institucionales, especialmente los relacionados con el mercado de trabajo.

Los resultados también parecen indicar que la introducción de nuevas tecnologías tiene un sesgo hacia la contratación de trabajo cualificado y que la inversión en actividades de I+D, aunque no se traduzca en la introducción de nuevas tecnologías, hace que las empresas incrementen la contratación de científicos en el corto plazo; a diferencia de la inversión en otras actividades de innovación que no produce efectos significativos. Estos resultados destacan la importancia de realizar reformas estructurales orientadas a mejorar el sistema nacional de innovación y en particular el sistema educativo, que permitan que las empresas puedan invertir en proyectos de innovación lo suficientemente avanzados. Estas políticas están relacionadas con la creación de universidades y laboratorios públicos, que fomenten la formación de personal cualificado y que permitan que las empresas aprovechen el conocimiento tecnológico para sus procesos de innovación.

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Apéndice

APÉNDICE 1

ATT DE LOS DIFERENTES TRATAMIENTOS EN EL CRECIMIENTO DEL EMPLEO
(*cto_empleo*)

ATT					
T_i	(1) *cto_empleo*	(2) *cto_ directivos*	(3) *cto_ cientificos*	(5) *cto_ tecnicos*	(6) *cto_resto*
(T1) *solo_producto*	0,043	0,030	0,087***	0,007	–0,012
	(0,123)	(0,025)	(0,030)	(0,038)	(0,042)
(T2) *solo_proceso*	0,034	0,033	0,088***	0,072**	0,029
	(0,028)	(0,020)	(0,024)	(0,032)	(0,035)
(T3) *producto_proceso*	0,136***	0,121***	0,175***	0,054	0,058
	(0,0296)	(0,031)	(0,039)	(0,039)	(0,042)

Nota: Los errores estándar se encuentran entre paréntesis.
La significancia está representada por: *** p<0,01; ** p<0,05; * p<0,1.

MODELO *PROBIT* - PUNTAJE DE PROPENSIÓN – PARA CRECIMIENTO DEL EMPLEO
(*cto_empleo*)

Variables	(T1)	(T2)	(T3)
	solo_producto	*solo_proceso*	*producto_proceso*
ln_empleo12	0,0703**	0,105***	0,140***
	(0,0314)	(0,0276)	(0,0295)
Exportadora	0,0260	0,00425	–0,0852
	(0,101)	(0,0875)	(0,0859)
ln_ventas12	–0,0200	–0,0236*	–0,0142
	(0,0159)	(0,0140)	(0,0184)
Creada	0,0737	0,0533	0,362
	(0,238)	(0,222)	(0,270)
Extranjera	0,238*	0,0501	0,331***
	(0,130)	(0,117)	(0,117)
Inversión en capital fijo	–0,719***	–0,828***	–1,093***
	(0,0615)	(0,0533)	(0,0568)
Manufactura	0,331*	0,332**	0,876***
	(0,169)	(0,150)	(0,159)
Servicios	0,203	–0,0958	0,409***
	(0,163)	(0,148)	(0,157)
Comercio	–0,350**	0,0375	–0,410**
	(0,170)	(0,149)	(0,167)

Variables	(T1)	(T2)	(T3)
	solo_producto	*solo_proceso*	*producto_proceso*
Provincia	–0,0707	–0,213***	0,142**
	(0,0657)	(0,0570)	(0,0600)
ln_ventas12#Creada	–0,0158	–0,0248	–0,0280
	(0,0215)	(0,0196)	(0,0225)
Constante	–0,294	0,0773	–0,558**
	(0,238)	(0,213)	(0,256)
Observaciones	2,368	2,734	2,830

Nota: Los errores estándar se encuentran entre paréntesis.
La significancia está representada por: *** p<0,01; ** p<0,05; * p<0,1.
Los modelos *probit* para el resto de variables de resultado (*cto_directivos*, *cto_cientificos*, *cto_tecnicos* y *cto_resto*) se encuentran bajo pedido al autor correspondiente.

BALANCE DE COVARIADAS
cto_empleo

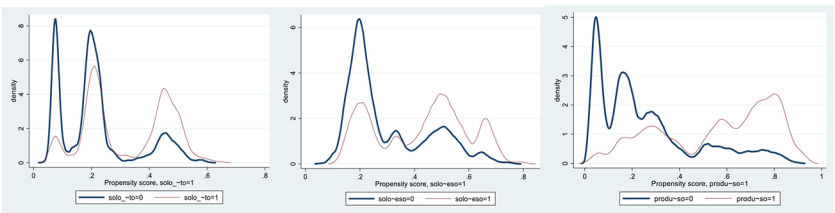
Covariadas	Diferencias estándar		Proporción en varianza	
	Primario	Ponderado	Primario	Ponderado
(T1) *solo_producto*				
ln_empleo12	0,191	–0,023	1,147	1,012
Exportadora	0,043	–0,002	1,115	0,995
ln_ventas12	0,020	–0,010	0,824	0,966
Creada	–0,048	–0,003	0,846	0,990
Extranjera	0,061	–0,013	1,250	0,958
Inversión en capital fijo	–0,616	0,004	1,183	1,001
Manufactura	0,232	–0,011	1,351	0,989
Servicios	0,247	0,013	1,049	0,999
Comercio	–0,495	–0,001	0,603	0,999
Provincia	–0,065	–0,017	0,999	0,999
ln_ventas12#Creada	–0,037	–0,004	0,800	0,965
(T2) *solo_proceso*				
ln_empleo12	0,244	0,001	1,076	1,017
Exportadora	0,086	0,006	1,228	1,014
ln_ventas12	0,139	0,002	0,706	0,984
Creada	–0,108	0,006	0,661	1,025
Extranjera	0,011	0,007	1,042	1,027
Inversión en capital fijo	–0,698	0,000	1,147	1,000
Manufactura	0,283	0,020	1,415	1,018
Servicios	–0,158	–0,012	0,908	0,990
Comercio	–0,086	–0,003	0,954	0,998
Provincia	–0,110	–0,006	0,992	0,999
ln_ventas12#Creada	–0,063	0,010	0,678	1,023

Covariadas	Diferencias estándar		Proporción en varianza	
	Primario	Ponderado	Primario	Ponderado
(T3) *producto_proceso*				
ln_empleo12	0,562	0,045	1,397	1,164
Exportadora	0,213	0,054	1,570	1,102
ln_ventas12	0,290	0,047	0,666	1,132
Creada	–0,115	–0,026	0,642	0,893
Extranjera	0,154	–0,013	1,663	0,964
Inversión en capital fijo	–1,010	–0,003	0,933	0,996
Manufactura	0,599	0,002	1,658	1,000
Servicios	0,080	–0,002	1,030	0,999
Comercio	–0,725	–0,001	0,368	0,997
Provincia	0,189	–0,036	0,959	1,017
ln_ventas12#Creada	–0,038	–0,023	0,836	0,899

Nota: Los balances de covariadas para el resto de variables de resultado (*cto_directivos*, *cto_cientificos*, *cto_tecnicos* y *cto_resto*) se encuentran bajo pedido al autor correspondiente.

GRÁFICOS DEL SUPUESTO DE SUPERPOSICIÓN POR TRATAMIENTO Y VARIABLE DE RESULTADO *CTO_EMPLEO*

(T1) solo_producto **(T2) solo_proceso** **(T3) producto_proceso**



Nota: Los gráficos de superposición para el resto de variables de resultado (*cto_directivos*, *cto_cientificos*, *cto_tecnicos* y *cto_resto*) se encuentran bajo pedido al autor correspondiente.

The relationship between price and financial stability in new monetary policy designs: the case of the US using the TVP-SVAR model*

La relación entre estabilidad de precios y financiera en nuevos diseños de política monetaria: el caso de Estados Unidos usando un modelo TVP-SVAR

Ömer Yalçinkaya**
Ali Kemal Çelik***
Hatira Sadeghzadeh Emsen****

Abstract

This study aims to explain the relationship between price and financial stability in monetary policy designs that have developed since the 1990s and to empirically examine the relationship between price and financial stability in the monetary policy designs of the US. To this effect, the study examines the time-varying structure of the relationship between price and financial stability in the US, where monetary policies are designed to achieve price stability, full employment and moderate long-term interest rate targets using the TVP-SVAR model for the period 1993:12-2020:12. The results of the study demonstrate the presence of a reciprocal relationship within the scope of the new environment hypothesis, which varies over time between price and financial stability in the US over the study period. These results broadly suggest the necessity of redesigning monetary policies in the US based on the propositions of the new environment hypothesis and considering the varying structure of the relationships, symmetrical or asymmetrical, between monetary and financial stability variables over time.

Key words: *Monetary policy designs, new environment hypothesis, US, TVP-SVAR.*

JEL Classification: *B40, C58, E44, E52.*

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** Department of Economics, Atatürk University, Erzurum, Turkey. E-mail: oyalcinkaya@atauni.edu.tr
*** Corresponding author, Department of Quantitative Methods, Ardahan University, Ardahan, Turkey. E-mail: alikemalcelik@ardahan.edu.tr
**** Independent Researcher, E-mail: sadeghzadeh.khatereh@gmail.com

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Resumen

Este trabajo pretende explicar la relación entre estabilidad de precios y financiera en nuevos diseños de política monetaria desarrollados desde los noventas y examinarla empíricamente para el caso de Estados Unidos. Para ello se examina una estructura variante en el tiempo usando un modelo TVP-SVAR para el periodo 1993:12-2020:12. Se encuentra una relación variable en el tiempo entre estabilidad de precios y financiera. Estos resultados sugieren la necesidad de rediseñar la política monetaria.

Palabras clave: *Diseño de política monetaria, TVP-SVAR.*

Clasificación JEL: *B40, C58, E44, E52.*

1. Introduction

Since the global financial crisis (GFC) of 2008-09, global economic growth has been propelled mainly by expansionary monetary policies, with advanced countries in exemplary positions, and has maintained a fixed rate of approximately 2-3% for the past few years (IMF, 2020). Despite the moderate recovery in global economic growth supported mainly by expansionary monetary policies and significantly low policy interest rates after the GFC, the stance of monetary policies remains extraordinarily accommodative when combined with low inflation rates below the target (Nair & Anan, 2020).

The ongoing expansionary monetary policies and the resulting increases in investor risk appetite lead to the accumulation of systemic risks in financial markets and thereby force a tight monetary policy stance. This emerging conjuncture in the global economy approximately ten years after the GFC not only reminds us of the global economic outlook in the pre-GFC period but also shows the difficulties faced by the central banks in designing monetary policies during a period of crisis (Fouejieu *et al.*, 2019). This view of the global economy after the GFC leads to the questioning and redesigning of traditional monetary policies based on inflation targeting, which have been implemented by a significant portion of central banks of both developed and developing countries since the 1990s (Smets, 2014; Sahoo, 2020). Thus, the GFC has reduced the effectiveness of policies that assume that in both developed and developing countries where output and inflation deficits are relatively balanced, the central bank's adjusted interest rates based on output and inflation deficit are compatible in ensuring price and financial stability (Mishkin, 2011; Fouejieu, 2017). Consequently, the GFC shows that even if price stability is achieved, there can be bubbles in financial asset prices, and the interest rates to achieve price and financial stability might not be compatible. Thus, financial risks cannot be eliminated only by monetary policies and instruments that enhance price stability (Borio, 2014; Kim & Mehrotra, 2017).

In these post-GFC conditions, central banks of both developed and developing countries should redesign their monetary policies to include instruments that can limit the effects of financial risks on output and inflation deficits and achieve financial stability without sacrificing price stability (Özatay, 2012; Roldán-Peña *et al.*, 2017). In these new monetary policy designs, central banks should seek to limit the effects of financial risks on output and inflation deficits with micro/macro prudent measures and also ensure that price stability supports financial stability (Karanovic & Karanovic, 2015; Sethi & Acharya, 2020). The theoretical foundations of these emerging new monetary policy designs after the GFC are based on the "new environment hypothesis" proposed in a study by Borio & Lowe (2002) just before the GFC. The "new environment hypothesis" criticizes traditional monetary policy designs within the framework of "The Conventional Wisdom Hypothesis" introduced by Schwartz (1995), which posits that price stability can provide financial stability. It states that price stability might not necessarily guarantee financial stability and that it is possible for price and financial stability to be observed concurrently in monetary policy designs (Issing, 2003).

To explain the relationship between price and financial stability of monetary policy designs since the 1990s, this study empirically examines the relations between price and financial stability in the monetary policy designs of the United States of America using nonlinear time series analysis. Following this objective, the time-varying nature of the relationship between price and financial stability in the US for the period 1993:12-2020:12 is econometrically analyzed using the time-varying parameter structural vector autoregression (TVP-SVAR) model. The TVP-SVAR model allows us to observe nonlinear trends in the relations between price and financial stability in the 1993:12-2020:12 period in the US and to examine the effects of timing (specific periods and maturities) in monetary policy designs. Thus, the relationship between price and financial stability in the US in the 1993:12-2020:12 period can be examined econometrically, before the GFC, when monetary policy designs developed, and after the GFC, where they changed significantly. To this effect, the US's financial stability variables measured in the form of an index encompassing various indicators of financial markets and price stability measured on the difference of actual inflation rates from the mean are used. In the US, where monetary policies were designed by the Federal Reserve System (FED) in line with the main objectives of price stability, full employment and moderate long-term interest rate, the time-varying structure of the relationship between price and financial stability in the 1993:12-2020:12 period was empirically analyzed with the TVP-SVAR model. This study constitutes the main purpose and motivation of this study. In this context, the research question of the study consists of econometrically testing whether the time-varying structure of the relations between price and financial stability in the US during the examination period (in certain years and maturities) can be explained by the traditional wisdom and/or new environment hypotheses. This study contributes to growing theoretical debates on monetary policy designs since the 1990s and the empirical studies that have emerged in the available literature after the GFC in three strands.

First, the study investigates the empirical validity of the theoretical explanations of the relationship between price and financial stability in monetary policy designs in the US for the period 1993:12-2020:12 within the scope of the traditional wisdom and/or new environment hypotheses. Therefore, the study intends to empirically determine the relationship between price and financial stability in the US during the sampling period and to determine the optimal level of the relationship between price and financial stability in the monetary policy designs of the US. Second, price stability is represented by the differences in the inflation rates from the mean, and financial stability is represented by variables in the form of an index. However, in the empirical literature, price stability is usually included in the econometric analysis, with more direct variables measured over actual inflation rates, while financial stability is measured through indicators such as the exchange rate, stock prices, financial sector loans, and other factors. Third, unlike studies that generally investigate the relationships between price and financial stability with a linear VAR model within the scope of time series analysis in the empirical literature, this study applies a nonlinear TVP-SVAR model to examine the varying nature of the relationships between price and financial stability over time. Therefore, the nonlinear trends of price and financial stability variables during the review period can be observed and examined to determine whether the timing before, during and after the GFC is important in discussing the relationship between price and financial stability.

In the second section after the introduction, the theoretical and empirical literature on the relationship between price and financial stability is presented, and the position of the study in the context of the extant literature is explained. In the third section, the econometric approach and the methodology of the study and data set are introduced. In the fourth section, the interaction between price and financial stability in the US for the period 1993:12-2020:2 is examined within the framework of the TVP-SVAR model, and the empirical findings of the study are discussed. In the last section, empirical findings and policy implications of the study are discussed, and recommendations for future studies are presented.

2. The relationship between price and financial stability: theoretical framework and empirical literature

2.1. Theoretical framework

The relations between price and financial stability in monetary policy designs have become an important policy agenda after the GFC. However, two different approaches that offer explanations for this mechanism have been documented in the theoretical literature since the 1990s. The first of these approaches is the "Traditional Wisdom Hypothesis" developed by Schwartz (1995). Schwartz (1995) posits that price stability supports and strengthens financial stability. The second approach is the "new environment hypothesis" proposed by Borio & Lowe (2002) and Borio *et al.* (2003), which posits that price stability might

not guarantee financial stability (Issing, 2003). Schwartz (1995) mentioned that monetary policy practices that cause price instability make the information flow between parties in a debt agreement asymmetric and hence are the main causative factor of financial instability. According to Schwartz (1995), instabilities in price as a result of an increment in money supply due to expansionary monetary policies make it difficult to estimate the real returns of financial investments. This circumstance results in the excessive overvaluation or undervaluation of asset prices and thereby causes financial instabilities. It is assumed that monetary policy practices that can provide price stability can prevent such information, estimation and valuation problems and provide financial stability (Schwartz, 1995). Similarly, Bordo & Wheelock (1998) stated that financial instability can be caused by unexpected changes in the money supply if there exists a strong correlation between price and financial stability. According to Bordo & Wheelock (1998), increments in commodity and security (real estate) prices due to changes in money supply cause bubbles in asset prices and financial instability. Monetary policy practices that focus on controlling changes in the money supply are deemed to provide price and financial stability simultaneously (Bordo & Wheelock, 1998). In a related study, Issing (2003) stated that a forward-looking strategy that aims at achieving and maintaining price stability in the medium-long term in monetary policy designs can also eliminate financial instabilities. This study argued that even if a short-term trade-off between the main goal of price stability and financial stability is experienced in such a future-oriented monetary policy design, such a conflicting mechanism will disappear in the medium-long term, and price stability will support financial stability (Issing, 2003). Other studies in the theoretical literature that explain the relationship between price and financial stability within the different contexts of the traditional wisdom hypothesis are Demirgüç-Kunt & Detragiache (1998), Hardy & Pazarbasioglu (1999), Bordo *et al.*, (2002), and Woodford (2012).

Borio & Lowe (2002) explained the relationship between price and financial stability from the perspective of the new environment hypothesis. They juxtaposed that financial instability can be observed even when price stability is achieved and that monetary policies should be designed in consideration of both financial stability and price stability. According to Borio & Lowe (2002), monetary policies with high credibility can ensure price stability and improve the expectations of economic actors. The improvement in medium- to long-term expectations causes the formation of bubbles in debt asset prices and, consequently, the accumulation of systemic risks in financial markets. It is therefore assumed that monetary policy designs that do not provide for such circumstances in financial markets through the expectations channel cannot prevent but rather deepen financial instabilities (Borio & Lowe, 2002). In its most general terms, systemic risk is defined by the International Monetary Fund (IMF), Bank for International Settlements (BIS) and the Financial Stability Board (FSB) (2009), as resulting from disruptions in some or all of the financial system and has the potential to have significant negative consequences on the real economy. It is defined as the risk of deterioration of financial services. On the basis of this

definition, there are negative externalities that arise from malfunctions in any of the financial system elements in the form of instruments, institutions and markets, and the effects of these externalities on the real economy are emphasized (IMF-BIS-FSB, 2009).

In a related study, Rajan (2005) attributed inflation to changes in interest rates. The study argued that the basis of financial instability is the adjustments in the risk appetite of economic actors concerning changes in inflation and interest rates. According to Rajan (2005), inflation and interest rates are relatively low in an economic environment where price stability is achieved. However, the risk appetite of economic actors in such an environment with an advanced financial system increases, and they tend to use alternative tools that will provide higher returns amidst higher risks. This situation, which can plunge an economy into financial instabilities, requires that monetary policies be designed with a thorough comprehension of the factors that reduce the risk appetite of economic actors. This approach will reduce the tendency of bubbles in debt asset prices and the associated accumulation of systemic risks in financial markets over time (Rajan 2005). These findings regarding monetary policy designs also corroborate the findings of studies by Leijonhufvud (2007). Leijonhufvud (2007) states that monetary policies aiming only at reducing the changes in inflation rates and ensuring price stability cannot prevent financial instability caused by credit asset price bubbles in financial markets but can also feed them in certain periods or conditions. Under the conditions of political or market pressures on central banks and being asymmetrical, low inflation rates can harbor the formation of credit asset price bubbles, and focusing on price stability can lead to policies that could threaten financial stability in the long run. For this reason, Leijonhufvud (2007) states that it is necessary to design central banks in a way that can eliminate the negative effects of monetary policies on financial stability and to take care of financial stability in the long run as well as price stability (Leijonhufvud, 2007). Other studies documented in the theoretical literature on the relationship between price and financial stability based on different perspectives of the new environment hypothesis include White (2006), Borio (2014b), Smets (2014), and Billi and Verdin (2014). Other studies documented in the theoretical literature on the relationship between price and financial stability based on different perspectives of the new environment hypothesis include White (2006), Borio (2014b), Smets (2014), Billi and Verdin (2014).

2.2. Empirical literature

Although the relations between price and financial stability have been explained in the theoretical literature from the perspectives of both the traditional wisdom hypothesis and the new environment hypothesis since the 1990s, studies on the subject matter in the available empirical literature coincide with the period after the GFC. Although the empirical literature on the relationship between price and financial stability shows a certain development after GFC, there is a limited number of studies on the subject matter. An examination of the empirical

literature reveals a study by Granville & Mallick (2009) on countries in the Euro area as one of the pioneering studies that examine the relationship between price and financial stability. In this study, the relationships between price stability represented by the actual inflation rate and financial stability represented by various financial variables (nominal effective exchange rate, stock prices and the ratio of banking sector loans to deposits) were analyzed within the scope of time series analysis with quarterly data for the period 1994: Q1-2008: Q2. The estimation result of their analysis based on the output of the established linear vector autoregression (VAR) model shows a reciprocal relationship between price and financial stability in countries in the euro area with price stability supporting financial stability. Similarly, the results that support the validity of the traditional wisdom hypothesis on the relations between price and financial stability were found in a related study by Frappa & Mésonnier (2010) on 17 developed OECD member countries using probit regression analysis within the scope of panel data analysis with annual data for the period 1980-2017.

Dhal *et al.* (2011) conducted a study on India to investigate the relationship between price stability (represented by the actual inflation rate) and financial stability (calculated in the form of an index based on various indicators related to the stability of the Indian banking sector). The study was designed within the scope of time series analysis with quarterly data covering the period 1995: Q1-2012: Q3. The result of their analysis based on the linear VAR model reveals that the relationship between price and financial stability in India is reciprocal. They found that financial stability supports price stability; however, price stability impedes financial stability. Empirical results that support the validity of the new environment hypothesis on the relationship between price and financial stability were found in studies by Blot *et al.* (2015) and Sethi & Acharya (2020).

Blot *et al.* (2015) examined the relationship between price stability represented by the actual inflation rate and financial stability calculated in the form of an index that encompasses various indicators related to the stability of the banking and finance sector of the US and countries in the Eurozone for the period 1993: M12-2012: M12 and 1999: M1-2012: M12. The results of the analysis within the framework of dynamic conditional correlations (DCCs) and the linear VAR model reveal that the relationship between price and financial stability in the US and Europe is reciprocal. Similar to findings by Dhal *et al.* (2011), they found that financial stability supports price stability and that price stability impedes financial stability. Sethi & Acharya (2020) investigated the relationship between price stability, captured as the actual inflation rate, and financial stability, represented by variables such as house prices and returns, with quarterly data from the period 1997: Q1-2016: Q3 on the Philippines, South Korea, Israel, Indonesia and Thailand. The empirical result of their analysis with a linear VAR model shows that in these five countries, where monetary policy designs are based on an inflation targeting regime, there is a negative relationship between price and financial stability, with price stability hindering financial stability. Research findings that reveal a negative relationship between price and financial stability are based on the use of Bayesian VAR and vector error correction (VEC)

models in different periods within the scope of time series analysis. A study on Germany (Euro area) applied Bayesian VAR (Van Roye, 2011). In the context of India, the VEC (Ramesh Babu and Venkateswarlu, 2017) and VAR (Sahoo, 2020). Unsurprisingly, all these studies concluded that financial instabilities in the relevant countries negatively affect and prevent price stability.

Following the review of the relevant literature, this study applies the TVP-SVAR model to econometrically examine the relationships between price stability (measured as the difference of inflation rates in the US from their mean) and financial stability (measured in the form of an index that encapsulates different financial indicators). Monthly data set for the period 1993:12-2020:12 is used. Within the scope of the study, there is an objective to econometrically determine which of the traditional wisdom and/or new environment hypotheses best explain, concerning time, the changing nature of the relationship between price and financial stability represented by more direct and inclusive variables in the context of the US. The findings of the study are thought to contribute to the emerging empirical literature after the GFC and largely support the new environment hypothesis by examining the variables used to represent price and financial stability using econometric methods that take into account nonlinearity in variables and the time-varying relationships between price and financial stability.

3. Econometric methodology and data

In this part of the paper, explanations of the econometric methodology used in the study, which aims to empirically examine the time-varying nature of the relationship between price and financial stability in the US as well as the data set, are presented. The structure of the TVP-SVAR model based on time series analysis methodology and the nature and sources of data used in the study are explained in the following subsections.

3.1. Time-varying parameter structural vector autoregression model (TVP-SVAR)

The TVP-SVAR model was introduced by Primiceri (2005) by extending the linear vector autoregression (VAR) and structural vector autoregression (SVAR) models developed by Sims (1986) and Shapiro & Watson (1988). The TVP-SVAR model involves eliminating variabilities in parameters following the determined order of the endogenous variables in the VAR and SVAR models. TVP-SVAR models also relax the assumptions that the parameters and structural shocks follow a linear process. In a TVP-SVAR model, following the determined order of endogenous variables, parameters and structural shocks do not change; however, they can follow a linear or nonlinear process, and the time-varying effects of the parameters of the endogenous variables as well as structural shocks are examined. In a TVP-SVAR model where the parameters of the endogenous variables and the variance-covariance matrix are allowed to

change over time, time-dependent changes and nonlinear trends are likely to occur in the lag structure of the variables (Dahem *et al.*, 2017).

A TVP-SVAR model that is based on a time series analysis methodology with a stochastic volatility model makes it possible to capture linear and nonlinear trends in the simultaneous relationships between endogenous variables and to eliminate problems associated with the varying variance in the time structure of structural shocks (Primiceri, 2005). In the TVP-SVAR model, the time-varying relationships between endogenous variables are assumed to follow a first-order random walk process and are investigated with the following regression equation:

$$Y_t = c_t + \beta_{1t} y_{t-1} + \ldots + \beta_{st} y_{t-s} + e_t, \qquad e_t \sim N(0, \Omega_t) \tag{1}$$

Here, the terms Y_t and c_t indicate the endogenous variables and constant term vector in a $k \times 1$ dimension. The terms β_{it} and Ω_t indicate the variance-covariance matrix of coefficients and residuals that varies over time in the $(k \times k)$ dimension. The recursive identification Ω_t term for structural shocks can be differentiated as follows:

$$\Omega_t = A_t^{-1} \sum_t \sum_t^{'} \left(A_t^{-1}\right)^{'} \tag{2}$$

The Σ_t and A_t terms in the equation show the diagonal matrix of the time-varying components of the structural shocks in the endogenous variables. The lower triangular matrix of the covariance components that enables the determination of the time-varying relationships between the endogenous variables can be specified as follows:

$$\sum_t = \begin{pmatrix} \sigma_1 & 0 & \ldots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \ldots & 0 & \sigma_k \end{pmatrix}, A_t = \begin{pmatrix} 1 & 0 & \ldots & 0 \\ \alpha_{21,t} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{k1,t} & \ldots & \alpha_{k,k-1,t} & 1 \end{pmatrix} \tag{3}$$

After this transformation process, the equation for the TVP-SVAR model in Equation 1 can be rewritten as follows:

$$y_t = X_1 \beta_t + A_t^{-1} \sum_t \varepsilon_t, \qquad \varepsilon_t = \sim N(0, I) \tag{4}$$

Here, $t = s + 1, \ldots, n$ is a representation of the process of modeling varying parameters as specified by Primiceri (2005). However, in the lower triangular matrix, the clustered vector representation of the elements in the form of $\alpha_t = \left(\alpha_{21}, \alpha_{31}, \alpha_{32}, \ldots, \alpha_{k,k-1}\right)^{'}$ is used. In this notation, the variance-covariance

matrix of the time-varying residuals is $h_t = (h_{1t},\ldots,h_{kt})'$ and $h_{jt} = log\sigma_{jt}^2$, $(j = 1,\ldots,k)$, while the parameters in the equation do not strictly have to follow a stationary process of AR(1) but a random walk process. Under these assumptions, the structure of the β_t, α_t and h_t parameters can be defined as follows:

$$(1)\qquad \begin{aligned} \beta_{t+1} &= \beta_t + \mu_{\beta t}, \\ \alpha_{t+1} &= \alpha_t + \mu_{\alpha t}, \\ h_{t+1} &= h_t + \mu_{ht}, \end{aligned} \qquad \begin{pmatrix} \varepsilon_t \\ \mu_{\beta t} \\ \mu_{\alpha t} \\ \mu_{ht} \end{pmatrix} \sim N\left(0, \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \sum_{\beta} & 0 & 0 \\ 0 & 0 & \sum_{\alpha} & 0 \\ 0 & 0 & 0 & \sum_{h} \end{pmatrix}\right)$$

Here, when $t = s + 1,\ldots, n$, the parameters $\beta_{s+1} \sim N\left(\mu_{\beta 0}, \sum_{\beta 0}\right)$, $\alpha_{s+1} \sim N\left(\mu_{\alpha 0}, \sum_{\alpha 0}\right)$ and $h_{s+1} \sim N\left(\mu_{h0}, \sum_{h0}\right)$ are normally distributed. The term ε_t in the equations represents the elements of the diagonal matrix corresponding to the covariance matrix of structural changes. Here, $\mu_{\beta t}$ shows the lag coefficients, $\mu_{\alpha t}$ shows the simultaneous coefficients, and μ_{ht} shows the time-varying structural changes in the standard errors. The transformation of (A_t) in Equation 4 into a lower-triangular matrix transforms the VAR system into a recursive definition, rendering the estimation of the models in the SVAR structure easier. To predict the TVP-SVAR model in Equation 4, the structural shocks derived from the variance-covariance matrix of the residuals from the reduced-form equation should be determined. Then, restrictions imposed on the covariance matrix, ε_t, of the structural shocks in the A matrix are defined in Equation 5. In the TVP-SVAR model as specified in Equation 4, the optimal lag length that eliminates autocorrelation in the residuals and the order of the endogenous variables in matrix A should be determined. The model is then estimated with the Markov Chain Monte Carlo (MCMC) method based on the random walk process and the Bayesian algorithm (Nakajima, 2011).

3.2. Dataset

The study uses monthly data obtained from the Federal Reserve Bank of St Louis FED (FRED Economic Data) database for the period 1993:12-2020:12. Data obtained from the FRED database and curated into a financial stability index to represent the financial stability (instability) level of the US for the study period 1993:12-2020:12 with regard to the scope of the study. The study considers four basic variables. The policy interest rate and the money supply variables that direct the relationship between price and financial stability through price stability, the financial stability and the monetary transfer mechanism constitute the basic variables for this study. Data on financial stability, policy interest rate and money supply variables are obtained directly from the FRED database. Data

on the price stability variable, however, were curated by the authors using the actual inflation rate data obtained from the FRED database.

The financial stability (instability) variable symbolized as FS is drawn from the STLFSI2 Index (St. Louis Fed Financial Stress Index) values. This index captures the level of stability (stress) in the US financial markets calculated from different financial indicators contained in the FRED database. STLFSI2 was calculated using principal component analysis (PCA). This index accounts for the statistically explanatory degree of the combined movements of 18 financial indicators that directly, and from diverse perspectives, reflect the stability (stress) level of financial markets. The STLFSI2 index is designed and calculated to move weekly around a mean of zero since 1993:12. Values below 0 indicate a decreased level of stress and instability in financial markets, and values above 0 indicate increments in the level of stress and instability in financial markets. For comprehensive information on the scope and methodology of the STLFSI2 index, see (St. Louis Fed Financial Stress Index). The data on the policy interest rate variable, symbolized as FF in the study model, were obtained as the values of the Federal Reserve Bank's (FED) Effective Federal Funds Rate policy interest rate in percentages from the FRED database. The data on the money supply variable, symbolized as MS, were taken as seasonally adjusted billions of dollars (M2 money stock) values from the FRED database.

Data on the price stability variable, symbolized as PS in the study model, were derived by the authors based on the actual inflation rate data obtained from the FRED database and the average inflation rate within the 2% band used by the FED as a measure in defining the price stability. (The criterion used by FED to measure the annual inflation rate for the US on the consumer price index (CPI) within the limit of 2% is defined as price stability (FED, www.federalreserve.gov 2020). Inflation rate data from the FRED database calculated as seasonally adjusted monthly percentage change values based on the CPI (2015 = 100) compared to the same month of the previous year were used to represent actual inflation rate data. In deriving the PS variable, the criterion that the annual average inflation rate should be within a limit of 2% pegged by the FED in measuring the price stability was used. Consequently, a new variable that consists of the average (potential) values of the inflation rate within a 2% band in the entire period was created. Then, the values of the average inflation rate variable created for the period 1993:12-2020:12 for the US were subtracted from the values of the actual inflation rate variable (taking its differences from the mean) for the period 1993:12-2020:12 to obtain the PS variable. Accounting for the uncertainty problems that arise from innovations and trends of filter-based methods such as Hodrick-Prescott, Kalman, and so on, which are used to calculate potential data under certain assumptions based on observed data, the average inflation rate was represented in the study with the FED's average inflation rates of 2% per year, used as a measure of the price stability in the US (Orphanides & Norden, 2002; Hamilton, 2017).

In the econometric analysis, annual growth rate values (calculated following previous years' same month values) of MS and PS variables were seasonally

adjusted from the relevant database. However, FS and FF variables are not periodically adjusted because they do not have seasonal characteristics. After the data transformation process, descriptive statistics on the FS, FF, MS and PS variables included in the econometric analysis for the period 1993:12-2020:12 are obtained and presented in Table 1.

TABLE 1
DESCRIPTIVE STATISTICS

Statistics	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
PS	0.188	0.207	3.498	–3.958	1.124	–0.407	4.101	25.39
FS	–62.05	–30.93	6469.6	–5655.4	719.1	0.011	41.82	20415.2
FF	18.30	4.962	245.4	–97.93	73.26	0.877	3.593	46.45
MS	6.284	5.993	25.99	0.316	3.540	2.948	16.15	2814.2
Observations	325	325	325	325	325	325	325	325

As seen in Table 1, the variables are ranked as FS, FF, MS and PS from largest to smallest in terms of the differences between the mean and median and the maximum and minimum statistical values and, therefore, the size of the standard deviation (Std. Dev.) statistical values. These findings show that the variables were ranked as FS, FF, MS and PS in terms of the magnitude of the changes they were exposed to during the study period and their differences from the mean values. However, the findings reveal that the changes in the FS and FF variables during the study period are much greater than the changes in the MS and PS variables. As shown in Table 1, the skewness, kurtosis and Jarque-Bera statistics of the PS, FS, FF and MS variables differ significantly from 0. This finding shows that the PS, FS, FF, and MS variables were relatively skewed and flattened distributions during the study period, which reveals that they did not exhibit a normal distribution.

4. Empirical findings

In this section, the relationship between price and financial stability in the US is examined empirically with the TVP-SVAR model within the scope of time series analysis methodology for the period 1993:12-2020:12. To this effect, the price stability (PS), financial stability (FS), policy interest rate (FF) and money supply (MS) variables in the study on the monetary policy designs of the US are declared endogenous. The variables are included in matrix A of the TVP-SVAR model as defined earlier in Equation 4, as PS, FS, FF and MS in respective order. The TVP-SVAR model equation defined to determine the time-varying effects of the relationships between PS, FS, FF and MS in the US

is estimated for the period 1993:12-2020:12. In determining the endogenous variables in the TVP-SVAR model and their subsequent rankings in matrix A, references were drawn from studies by Granville & Mallick (2009), Blot *et al.*, (2015) and Sethi & Acharya (2020) in the relevant empirical literature on the subject matter. (Winrats 10.0, Gauss 16.0 and OxMetrics 7.0 econometrics software packages were used in the analysis of the study data).

According to Çatık (2020), it is necessary to determine the movements (linear and nonlinear structures) of the variables included in the established TVP-SVAR model before proceeding with estimations (Çatık, 2020). Determining the linear structure of the variables in the model guides the econometric methodology and helps to obtain test statistics and results that are unbiased (Hoque and Zaidi, 2019: 996). To circumvent the aforementioned drawbacks of the study, the linear structure of the movements of the variables in the TVP-SVAR model over the analysis period is examined with linearity tests of Harvey & Leybourne (2007-HL) and Harvey *et al.* (2008-HR). The HL and HR linearity tests, as documented in the time series literature, can be used when variables are stationary or not at level values and, in any case, give consistent results. In the HL test, the linearity of the variables is examined with the Wald, W_T^*, type test statistics and in the HR test with the Wald, W_S, W_U and, W_λ type test statistics. If the Wald test statistics obtained in the HL and HR tests are greater than the critical values, the null hypothesis that "the variables are linear" is rejected, and then, a conclusion that the variables exhibit nonlinear trends during the period under review is arrived at (Harvey & Leybourne, 2007; Harvey *et al.*, 2008). (For comprehensive information on the methodology of these tests, see Harvey & Leybourne, 2007; Harvey *et al.*, 2008). HL and HR test results on the linear structure of the variables in the TVP-SVAR model are presented in Table 2.

TABLE 2
TEST OF LINEARITY RESULTS

Variables		HR				HL	
		W_S	W_U	λ	W_λ	W_T^*	
						%1	%5
PS		7.34[b]	17.71[a]	0.87	16.34[a]	16.77[a]	16.75[b]
FS		4.00	15.59[a]	0.86	14.00[a]	12.79	12.75[b]
FF		12.66[a]	4.67	0.00	12.66[a]	19.12[a]	18.97[b]
MS		0.85	16.05[a]	0.78	12.68[a]	21.55[a]	21.30[b]
Critical Values	*%1*	*9.21*				*13.27*	
	%5	*5.99*				*9.48*	

Note: The "a" and "b" signs in front of the test statistics calculated with ($\chi^2 = 2$) degrees of freedom indicate that the null hypotheses are rejected at the 1% and 5% significance levels, respectively. The term "λ" in the table indicates the weights of the W_S and W_U test statistics in the calculation of the W_λ test statistics.

The test results in Table 2 indicate that all variables are nonlinear at the 1% or 5% significance level following HR and HL test results. This conclusion is reached by rejecting the linearity null hypotheses since the Wald test statistics calculated for PS, FS, FF and MS variables are greater than the critical values at the 1% or 5% significance level. Since the PS, FS, FF and MS variables in the TVP-SVAR model exhibit a nonlinear distribution during the review period, it is necessary for the degree of stationarity of the variables to be investigated with unit root tests that account for nonlinearity (Cuestas & Garrant, 2011). Accordingly, the stationarity status of the variables in the TVP-SVAR model, symmetric and asymmetric properties of variables, deterministic and stochastic structure, etc., were considered, and Kapetanios *et al.* (2003-KSS) and Sollis (2009-SLS) unit root tests that incorporate nonlinear characteristics of the variables were used.

KSS unit root tests developed by Kapetanios *et al.* (2003) and SLS unit root tests by Sollis (2009) can be used in stationarity analysis when time-series data are nonlinearly distributed. However, the KSS and SLS unit root tests perform well under a set of assumptions when variables exhibit symmetric or asymmetric properties. The stationarity of nonlinear time series data is examined with an exponential and smooth transition autoregressive process in the KSS unit root test and an exponential or logistically smooth transition autoregressive process in the SLS unit root test. In KSS and SLS unit root tests, the stationarity of variables is examined using the demeaned (demeaned-D) and demeaned and detrended-DD forms. The null hypothesis that "there is a unit root in the series" is tested. If the KSS and SLS test statistics are greater than the absolute critical values, the null hypotheses are rejected, and the variables are said to be stationary over the review period (Kapetanios *et al.*, 2003; Sollis, 2009). For comprehensive information on the methodology of these tests, see Kapetanios *et al.* (2003) and Sollis (2009). The KSS and SLS unit root test results in the TVP-SVAR model in the form of DD are presented in Table 3.

TABLE 3
KSS AND SLS UNIT ROOT TEST RESULTS

Test Statistics		KSS		SLS	
Variables		DD	L	DD	L
PS		–3.46[b]	4	6.97[b]	4
FS		–4.77[a]	3	18.47[a]	2
FF		–4.18[a]	4	10.50[a]	3
MS		–3.45[b]	2	8.20[b]	2
Critical Values	*%1*	*–3.93*		*8.95*	
	%5	*–3.40*		*6.59*	

Note: The "[a]" and "[b]" signs in front of the test statistics indicate stationarity at the 1% and 5% significance levels, respectively. The optimal lag lengths determined for the variables based on the Akaike Information Criteria (AIC) are reported in column "L". Critical values for the KSS and SLS tests are taken from Kapetanios *et al.* (2003) and Sollis (2009), respectively.

Table 3 shows that all variables are stationary at level values [I(0)] at the 1% or 5% significance level following KSS and SLS unit root tests. This conclusion was reached with both KSS and SLS unit root test statistics calculated at the [I(0)] level for PS, FS, FF and MS variables greater than the absolute value of the critical values and, consequently, rejecting the null hypotheses of a unit root. Since all variables considered in the study are declared stationary at level values, the TVP-SVAR model defined in Equation 4 is estimated using the level values of the PS, FS, FF and MS variables. The optimal lag length of the estimated TVP-SVAR model to examine the time-varying relationships between the variables included in matrix A with PS, FS, FF and MS is obtained as 3 with marginal likelihood (ML) and according to the highest ML value. The efficiency results of the Bayesian MCMC algorithm with 12,000 iterations and 2,000 joint posterior distributions of the time-varying parameters of the TVP-SVAR (3) model estimated in the study are presented in Table 4.

TABLE 4
TVP-SVAR MODEL PARAMETER ESTIMATION RESULTS

Parameters	Mean	Standard Deviation	Confidence Intervals (%95)	CD	IF
$(\Sigma_\beta)_1$	0.0228	0.0025	[0.0183-0.0284]	0.936	26.61
$(\Sigma_\beta)_2$	0.0181	0.0016	[0.0153-0.0215]	0.728	15.64
$(\Sigma_\alpha)_1$	1.1498	1.1036	[0.0950-0.1550]	0.224	96.12
$(\Sigma_h)_1$	1.1498	0.1036	[0.9587-1.3605]	0.125	92.21
$(\Sigma_h)_2$	1.6593	0.1429	[1.3976-1.9527]	0.743	36.09

From Table 4, the posterior distributions of the parameters in the TVP-SVAR (3) model converge, and the MCMC algorithm produces effective results. Thus, the null hypotheses stating that the posterior distributions of the parameters converge in the CD test (Geweke, 1992) were not rejected at the 5% significance level, and the IF (inefficiency factors) values were relatively low (the number of repetitions was sufficient for the posterior distributions of the parameters to converge). However, in the TVP-SVAR (3) model presented in the table, the lowest and highest IF values are 15.64% with $(\Sigma_\beta)_2$ in the time-varying structural change parameter of the lag coefficients and 96.12% with $(\Sigma_\alpha)_1$ and simultaneous coefficients, respectively. The results of the TVP-SVAR (3) model of the parameters $(\Sigma_\beta)_1$, $(\Sigma_\beta)_2$, $(\Sigma_\alpha)_1$, $(\Sigma_h)_1$ and $(\Sigma_h)_2$ on the efficiency of the MCMC algorithm are presented in Figure A1 in the Appendix section.

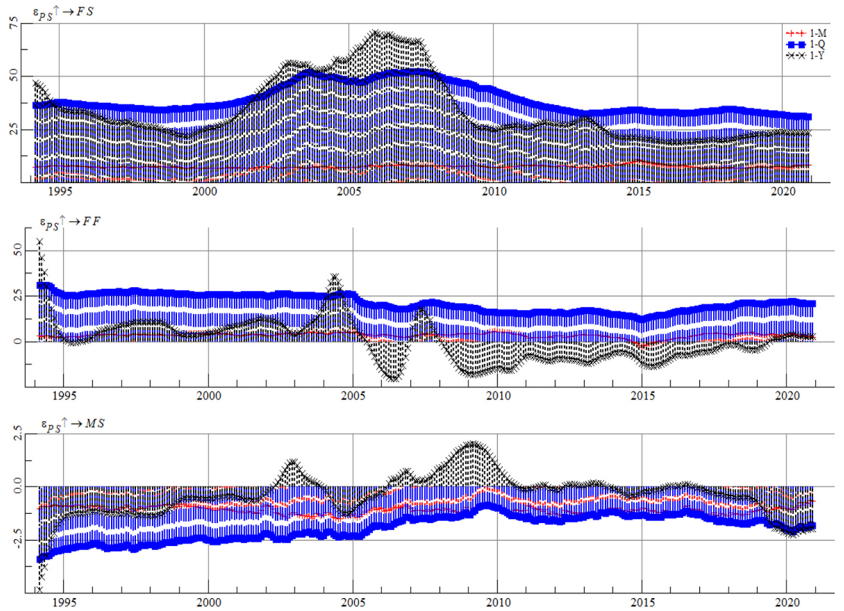
Graphs showing the course of innovation, stochastic volatilities and the time-varying simultaneous relationships between the PS, FS, FF and MS variables in the TVP-SVAR (3) model for the period 1993:12-2020:12 are presented in Figures A2, A3 and A4, respectively, in the Appendix section. From Figure

A2, it can be observed that the transformed forms of the PS, FS, FF and MS variables in the model follow a fluctuating innovation trend during the period under review, and these trends became evident in the years before, during and after the GFC. An examination of Figure 3 reveals that the PS, FS, FF and MS variables are listed as PS, FS, FF and MS in terms of the magnitude of the stochastic volatilities (the mean values of the structural shocks) during the sampling period. Additionally, stochastic volatilities that show similar trends in the PS, FS, FF and MS variables increased significantly in the 1999, 2005, 2010 and 2017 periods. Figure 4 depicts that the simultaneous relationships between the PS, FS, FF and MS variables stemming from the structural shocks specified recursively differ, to a certain extent, according to the variables and time. In addition, Figure 4 also shows that the simultaneous relationship between the PS and FS variables for the period 1993-2020 is positive and has become relatively stronger since 2000. This situation not only indicates that there were a priori simultaneous relationships between the PS and FS variables during the period review but also shows that the magnitude of these relationships changes over time. Moreover, Figure 4 also shows that similar findings are valid with regard to relationships between the PS, FS, FF and MS variable groups, albeit at different scales.

The results obtained from the analysis of the impulse-response functions that examine the time-varying relationships between the price stability, financial stability, policy interest rate and money supply in the US from the variance-covariance matrix of the parameters are presented in Figures 1, 2, 3 and 4. Figure 1 represents structural shocks caused by the price stability (PS), Figure 2 represents structural shocks originating from financial stability (FS), Figure 3 represents structural shocks originating from the policy interest rate (FF) variable, and Figure 4 shows structural shocks from the money supply (MS). The structural shocks from the money supply (MS) variable in Figure 4 depend on other time-varying variables and show the degree (direction/magnitude) of their responses according to term periods (1993-2020 period and short 1-month (1-M), mid-term 1-quarter (1-Q) and long-term 1-year (1-Y).

From Figure 1, it can be observed that the FS variable gives continuous positive responses to structural shocks in the PS at the 1-M, 1-Q and 1-Y terms (periods) during the period 1993-2020. Additionally, the magnitudes of these positive responses of the FS variable in the 1-Q and 1-Y terms (periods) were generally similar during the 1993-2020 period. However, the degree of positive responses increased in the period 2002-2009. These findings show that structural shocks in the PS increased the financial instability in the short, medium and long term over the entire study period. The effects that caused financial instability in the medium to long term became evident in the period 2002-2009. A thorough analysis of Figure 1 reveals that the FF variable gives continuous positive responses to structural shocks in PS at the 1-M and 1-Q terms during the 1993-2020 period; however, the degree of positive responses increased at the 1-Q term. The FF variable exhibits a positive response at 1-Y terms in the periods 1993-2004 and 2008-2009 and a negative response in the periods

FIGURE 1
TVP-VAR MODEL: TIME-VARYING RESPONSE TO SHOCKS IN THE PRICE STABILITY

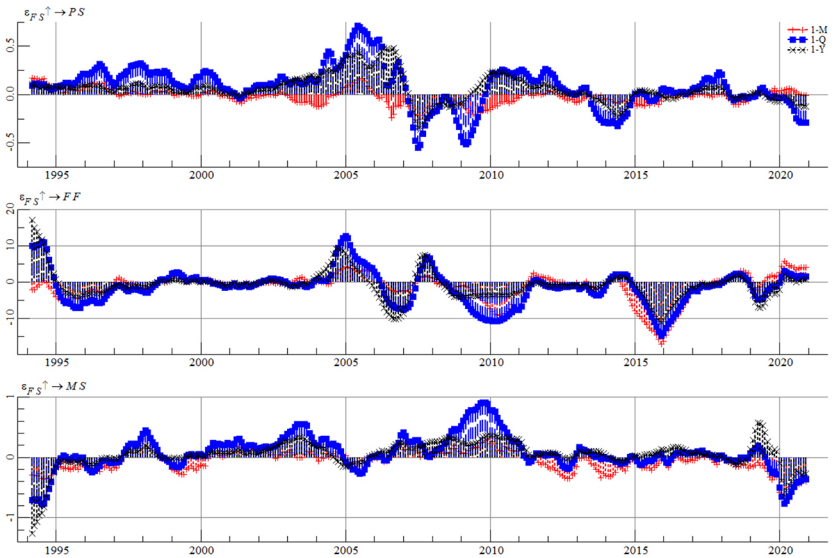


2005-2007 and 2010-2019. These findings show that structural shocks in PS increased policy interest rates in the short-medium term in the entire period 1993-2020. However, in the long term, there were increased policy rates in the periods 1993-2004 and 2008-2009 and decreased policy rates in the periods 2005-2007 and 2010-2019.

Moreover, in Figure 1, the MS variable exhibits continuous negative responses to structural shocks in PS at 1-M and 1-Q terms during the 1993-2020 period, with an increased degree of negative responses at 1-Q terms. The responses of the MS variable in 1-Y maturities are positive in the 2002-2004 and 2005-2016 periods and negative in the 1993-2001 and 2017-2020 periods. These findings show that structural shocks in PS decreased the money supply in the short-to-medium term throughout the 1993-2020 period. However, it increased in the long term in 2002-2004 and 2005-2016 and decreased in the periods 1993-2001 and 2017-2020.

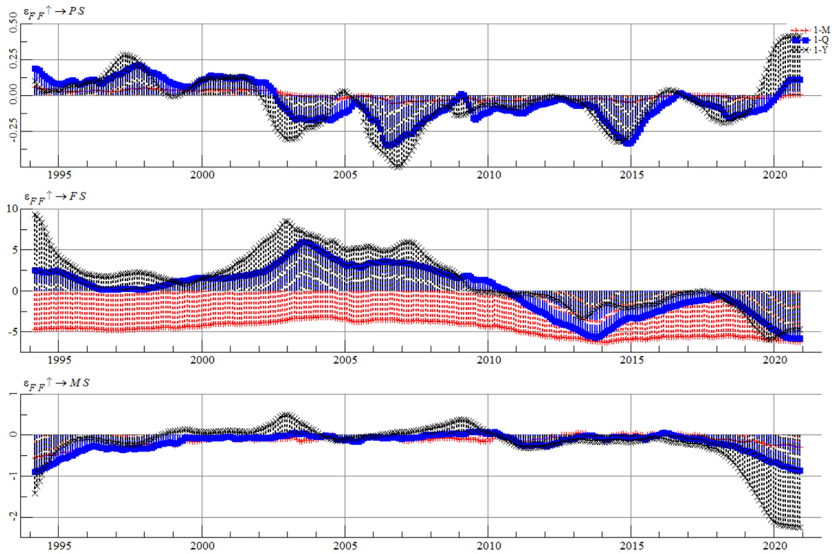
In Figure 2, the responses of the PS variable to structural shocks in FS at the 1-M, 1-Q and 1-Y terms are negative in the 2000-2001, 2006-2010 and 2014-2016 periods and positive in the 1993-1999, 2002-2005, 2011-2013 and 2017-2019 periods. On the other hand, the magnitudes of the negative-positive responses of the PS variable in the 1-M, 1-Q and 1-Y terms are generally similar, and the largest negative and positive responses are observed in the periods 2007-2008 and 2004-2005, respectively. These findings indicate that structural

FIGURE 2
TVP-VAR MODEL: TIME-VARYING RESPONSE TO SHOCKS IN FINANCIAL STABILITY



shocks in FS contribute to price stability in the short-, medium- and long-term periods 2000-2001, 2006-2010, and 2014-2016 and especially 2007-2008, 1993-1999, 2002-2005, 2011-2013, and 2017-2019. The results also show that structural shocks in FS caused price instability, especially in the 2004-2005 period. Figure 2 shows that the FF variable exhibits similar positive or negative responses to structural shocks in FS at the 1-M, 1-Q and 1-Y terms during the 1993-2020 period, and the degree of these reactions increased significantly after 2005. However, the FF variable gives the greatest positive and negative responses for the 1-M, 1-Q and 1-Y terms in the periods 2005-2008 and 2015-2016. These outcomes show that structural shocks in FS have had an impact on policy rates in the short, medium and long term during the 1993-2020 period. Notably, policy rates increased in the period of 2005-2008 and decreased in the 2015-2016 period. Figure 2 shows that the responses of the MS variable to structural shocks in FS at the 1-M, 1-Q and 1-Y terms are generally negative in the periods 1993-1997, 1999-2000, 2004-2006 and 2019-2020 and positive in the periods 2001-2003 and 2007-2018. Nevertheless, the MS variable exerts the greatest negative and positive responses in the 1-M, 1-Q and 1-Y terms in the periods 2019-2020 and 2008-2011. These findings demonstrate that structural shocks in FS decreased the money supply in the short, medium and long term in 1993-1997, 1999-2000, 2004-2006 and especially in the 2019-2020 period. An increment in the money supply was experienced in the periods 1998-2001-2003 and, especially, 2007-2018.

FIGURE 3
TVP-VAR MODEL: TIME-VARYING RESPONSE TO SHOCKS IN THE POLICY INTEREST RATE



A careful examination of Figure 3 reveals that the responses of the PS variable to structural shocks in FF at the 1-M, 1-Q and 1-Y terms are generally negative in the 2003-2018 period and positive in the 1993-2002 and 2019-2020 periods. This figure also depicts that the PS variable exerts increasing, parallel from short term to long term, negative and positive reactions in the periods from 2005-2007 and 2001-2002. Even though structural shocks to the FF cause price instability in the short, medium and long term in 1993-2002, 2019-2020 and especially in the 2001-2002 periods, they contribute to price stability in 2003-2018 and especially in the period from 2005-2007. Additionally, it can be inferred from Figure 3 that the FS variable exerts negative responses in 1-M terms and positive or negative responses in 1-Q and 1-Y terms with a similar magnitude to structural shocks in FF during the 1993-2020 period. However, the FS variable exerts stronger negative and positive reactions with parallel increments from the short term to the long term in the 2013-2015 and 2004-2009 periods, respectively. These findings demonstrate that while the structural shocks to the FF variable caused financial instability in the short term during the 1993-2020 period, they contributed to financial stability in the medium-long term in the 1993-2011 period and thereafter increased financial instabilities in the 2012-2020 period. Moreover, Figure 3 shows a negative response by the MS variable to structural shocks in FF in the 1-M, 1-Q and 1-Y terms for the 1993-1999 and 2005-2007 periods and positive responses of similar magnitude in the 2000-2004 and 2008-2010 periods. Figure 3 posits that the money supply

exhibits strong negative responses to structural shocks in FF in the 2019-2020 period and a negative response in 2009-2010. The results indicate that structural shocks FF decreased the money supply in the short, medium and long term in 1993-1999, 2005-2007 and especially in the 2019-2020 period but increased the money supply in 2000-2004, 2008-2010 and significantly in 2009-2010.

FIGURE 4
TVP-VAR MODEL: TIME-VARYING RESPONSE TO SHOCKS IN THE MONEY SUPPLY

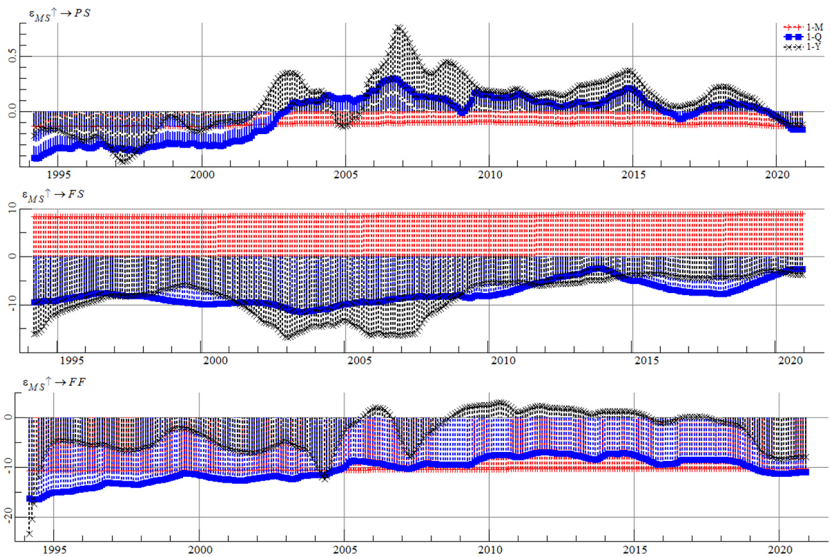


Figure 4 reveals that the PS variable exerts negative responses to structural shocks in MS for the 1-M term during the period 1993-2020 and positive or negative responses of similar magnitude in 1-Q and 1-Y terms. On the other hand, the PS variable gives strong negative and positive reactions that increase in a form directly parallel to the short term to long term in the periods 1993-2000 and 2005-2010, respectively. These outcomes indicate that structural shocks to MS contribute to price stability during the period under review. Notably, the price stability is observed in the short term and medium-long term in 1993-2003 and 2019-2020, and increments in the price instability are seen in the medium-long term in the period 2004-2018. Additionally, Figure 4 shows that the FS variable reacts positively to the 1-M term and negatively to the 1-Q and 1-Y terms during the period under review. However, the positive and negative reactions of the FS variable increased in a parallel form from the short term to the long term with stronger negative responses in the 2003-2010 period. These results show that structural shocks in MS caused short-term financial instability throughout the period under review but contributed to financial stability in the medium-long

term, and this effect became evident in the period 2003-2010. The FF variable responds negatively to structural shocks in MS at the 1-M and 1-Q terms and positive or negative responses of similar magnitudes at the 1-Y terms during the period under review. However, the FF variable exerts the strongest positive responses in 2004-2005 and 2009-2015 and negative reactions in 1993-1995 and 2004-2008 that increase in a form parallel to the short term to long term. These findings indicate that structural shocks sustained in MS decreased policy interest rates in the short-medium term during the study period and in the long term in 1993-1995 and 2004-2008. However, policy interest rates increased in the long term in the periods 2004-2005 and 2009-2015.

5. Conclusions

In this study, the relationship between price and financial stability of monetary policy designs is explained, and the relationship between price and financial stability in the US's monetary policy designs is examined by considering the propositions of traditional wisdom developed in the 1990s and the new environment hypotheses. To achieve this purpose, the time-varying nature of the relationship between the price stability, financial stability, policy interest rate and money supply in the US, where monetary policies are designed to achieve price stability, full employment and moderate long-term interest rate targets, is studied econometrically with the TVP-SVAR model for the period 1993:12-2020:12. The results of the estimated TVP-SVAR models are parallel with the empirical findings of studies by Dhal *et al.* (2011), Blot *et al.* (2015), Sethi & Acharya (2020) and Sahoo (2020), who found mutual relationships between price and financial stability and who corroborate the proposition of the new environment hypothesis in the theoretical literature that price stability may not necessarily guarantee financial stability.

The output of the TVP-SVAR model estimated for this study reveals that the relationship between the price stability, financial stability, policy interest rate and money supply is mutual and varies significantly over time (short-, medium- and long-term periods in the years considered in the study) in the monetary policy designs of the US. Models established to investigate the relationship between the price and financial stability in the study show that price instabilities prevent financial stability by increasing the accumulation of systemic risk in financial markets in the short, medium and long term during the study period. Contrasting results were observed for certain periods and times in which financial instabilities supported or prevented the price stability by either decreasing or increasing the differences in the inflation rates from the mean in the sample period. Moreover, mixed results were obtained on the effects of price instabilities in preventing financial stability in the period of 2002-2009. Financial instabilities were found to prevent price stability in the period 2004-2005, and supportive effects of financial instabilities on price stability were noticed in the period 2007-2008. The theoretical background of these results, which reveals that price stability

might not guarantee financial stability and could even feed financial instability in certain periods or conditions, is in line with the study of Leijonhufvud (2007). In fact, in the study of Leijonhufvud (2007), price stability can prevent financial stability by increasing the accumulation of systemic risk in financial markets in certain periods or conditions.

In TVP-SVAR models where the relationship between price stability and the policy interest rate is examined, it is found that price instabilities increase or decrease policy interest rates by tightening or loosening monetary policy stances. The results from such models also indicate that changes in policy rates support or prevent price stability by decreasing or increasing the differences in the inflation rates from the mean values in the sample period. The results from such models, notably, reveal the effects of price instabilities on increasing policy rates and evidence that variabilities in policy interest rates support price stability were found in the 2004-2008 period. In models that focused on examining the relationship between price stability and money supply, it is found that price instabilities during the sample period reduce or increase the money supply by altering the opportunity cost of holding cash. These variabilities in the money supply were found to support or prevent price stability by either reducing or increasing the differences in the inflation rates from the mean values. Notably, the effects of price instabilities on reducing the money supply and, consequently, hindering price stability became evident in the 2004-2010 period.

In the models in which the relationship between financial stability and the policy interest rate is investigated, the results indicate that during certain periods and terms, financial instabilities increase or decrease policy interest rates, thereby resulting in a tighter or loosened monetary policy stance. Changes in policy rates were found to support or inhibit financial stability by either decreasing or increasing the accumulation of systemic risk in financial markets. Additionally, such models show that financial instabilities increase policy interest rates, and the reverse effects of variabilities in policy rates on financial stability were observed in the period 2004-2009. The study results also reveal certain periods and terms in the sample period where financial instability reduced or increased the money supply by changing the opportunity cost of holding money. Such changes in the money supply support or prevent financial stability by reducing or increasing the accumulation of systemic risk in financial markets. This finding became evident in the period 2004-2010. TVP-SVAR models established to examine the relationship between the money supply and policy interest rate show that changes in the money supply during the sample period increase or decrease policy interest rates through tight or loose monetary policies. Changes in the money supply were found to result in decreases in the policy interest rate in the period 1993-2000. The reverse effect indicates that changes in the policy interest rate decrease or increase the money supply by changing the opportunity cost of holding money. This effect became evident in the period 2016-2020.

These results show the bidirectional relationship between price stability, financial stability, policy interest rate and money supply in the US and changes over time in the periods before, during and after the 2008 global financial crisis.

The time factor is important in the relationship between these variables. These results show that the reciprocal relationship between the price stability, financial stability, policy interest rate and money supply can change symmetrically and asymmetrically over time. Thus, it broadly suggests that policy interest rates that ensure price and financial stability might not always be compatible and that price stability might not always guarantee financial stability. In fact, the results of the study show that changes in the policy interest rate and/or money supply can provide price stability in certain periods and/or prevent financial stability by feeding systemic risks in financial markets. These results, which are theoretically compatible with the new environment hypothesis, show that it is necessary to regulate price stability, policy interest rate and money supply changes with a simultaneous approach that can prevent the accumulation of systemic risks in financial markets. In this context, as suggested in the studies of Borio & Lowe (2002), Rajan (2005) and Leijonhufvud (2007), in the design of monetary policies, in regulating the relations between price stability, financial stability, policy interest rate and money supply, there are expectations, risk factors, which are financial systemic risk factors. It is necessary to consider the effects of changes in the credit market appetite and loan asset prices together. Nevertheless, these results point to emphasizing the need to design monetary policies with consideration of the time factor in the symmetrical and asymmetrical bidirectional relations between price stability, financial stability, policy interest rate and money supply. Based on these findings, monetary policies in the US must be redesigned within the framework of the new environment hypothesis with considerations to the changing nature of the relationship between monetary and financial variables over time. To this effect, US monetary policies implemented by the FED to achieve price stability, full employment and moderate long-term interest rate targets should be designed with substantial depth in their scope and purpose, to reduce the trade-offs between monetary and financial stability. The approach should incorporate a variety of tools that can direct the timing of the relationship between monetary and financial variables. In doing so, it will be possible to reduce the trade-offs between monetary and financial stability, regulate the relationship that varies symmetrically or asymmetrically over time between these variables, and ensure that financial stability and price stability support each other over time. Otherwise, the reciprocal relationship between monetary and financial stability is likely to be bound to certain conditions and periods, as depicted by study findings. Thus, financial instabilities will continue to threaten monetary stability and the output gap, as observed in the 2008 global financial crisis. In this study, it is evaluated that these results and policy implications for the explanation of the relations between monetary and financial stability in the monetary policy designs of the US could be valid to a certain extent in terms of the monetary policy designs of a significant part of developed and developing countries. In fact, after the 2008 global financial crisis, monetary policies were redesigned by a significant part of developed and developing countries with an understanding that aims to support monetary stability with financial stability, either explicitly or implicitly. Future empirical studies in line with the subject

matter can examine the linear and nonlinear distributions of price and financial stability variables during the period under review within the context of different developed and developing countries to contribute to the development of the emerging empirical literature following the 2008 global financial crisis.

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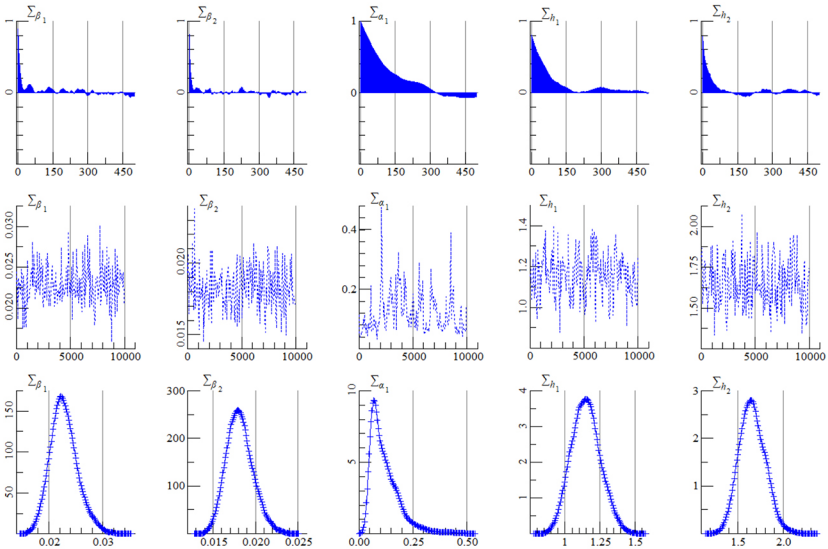
APPENDIX

FIGURE A1
ESTIMATION RESULTS FOR THE TVP-SVAR MODEL PARAMETERS



Note: The upper, middle and bottom parts of the graphs show sample autocorrelation, trends and successive densities of time-varying parameters in the TVP-SVAR (3) model, respectively.

FIGURE A2
TIME SERIES GRAPHS OF THE TVP-SVAR MODEL VARIABLES

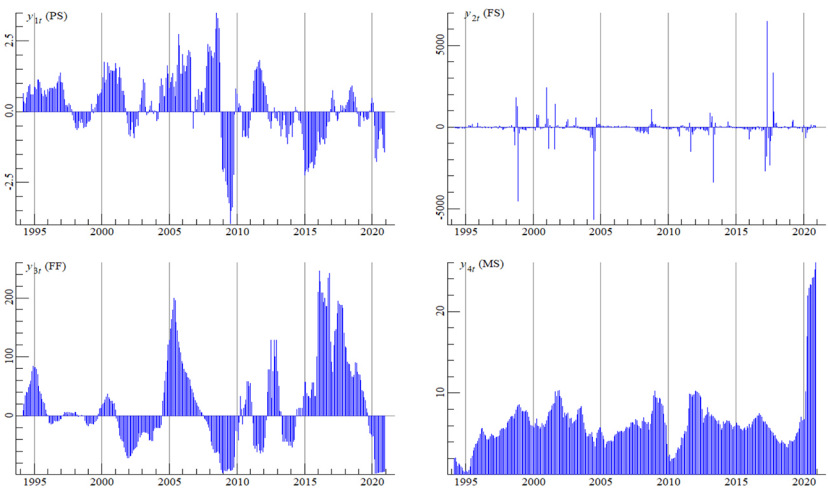
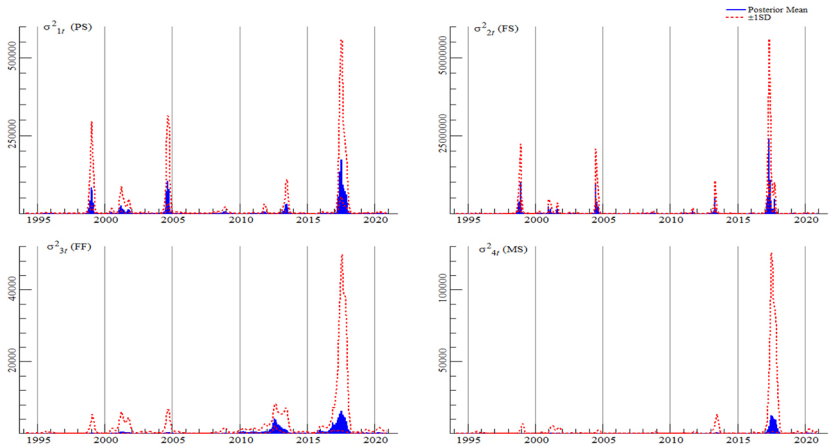
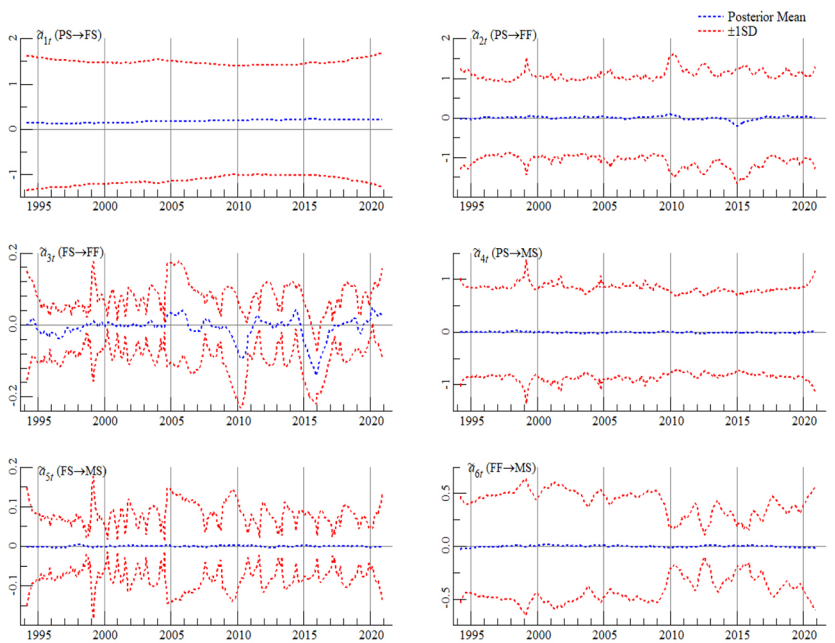


FIGURE A3
STOCHASTIC VOLATILITY OF THE VARIABLES IN THE TVP-SVAR MODEL



Note: The blue and continuous lines in the graphs indicate the successive means of the time-varying parameters in the TVP-SVAR (3) model, and the red and dashed lines indicate plus/minus standard deviations at a 99% confidence interval.

FIGURE A4
SIMULTANEOUS RELATIONSHIPS BETWEEN VARIABLES IN THE TVP-SVAR MODEL



Note: See explanations in Figure A3.

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