REVISTA MEXICANA DE ECONOMÍA Y FINANZAS Nueva Época REMEF (THE MEXICAN JOURNAL OF ECONOMICS AND FINANCE)

Revista Mexicana de Economía y Finanzas, Nueva Época

Volumen 16 Número 3, Julio - Septiembre 2021, pp. 1-25, e636

THE ECONOMICS AND FINANCE EFFECTS OF THE COVID-19 PANDEMIC
Editor: Dr. Ignacio Perrotini

DOI: https://doi.org/10.21919/remef.v16i3.636

(Received: February 22, 2021, Accepted: June 18, 2021.
Published: June 23, 2021)

imef fundación de investigación

Informality, Gender Employment Gap, and COVID-19 in Mexico: Identifying Persistence and Dynamic Structural Effects

Jorge O. Moreno[1] - Universidad Autónoma de Nuevo León, México, México
Cecilia Y. Cuellar - Universidad Autónoma de Nuevo León, México, México

Abstract

The objective is to analyze the impact of the COVID-19 pandemic on the dynamics of the Mexican labor market (formal-informal employment) by gender. It is built consistent micro-founded time-series from 1987:Q1 to 2019:Q4 using the Mexican urban employment surveys and estimate a VAR model linking aggregate production and each market segment. Our results suggest significant adverse effects on formal employment resulting from the COVID-19 pandemic, with lengthy job recovery for females and males. The informal sector in both genders presents a lower forecasted response to the initial production shock but substantial observed employment losses, potentially linked to structural changes in the market. In the COVID-19 crisis, the informal sector is not a substitute for formal employment losses. The complexity of this crisis suggests crafting policies to improve the easiness of the market to enhance formal job recovery while promoting gender equality. Our main contribution is to estimate the diverse employment losses by segments and a critical structural change in the labor market dynamics resulting from the COVID-19 pandemic focusing on urban employment.

JEL Classification: E24, E26, J21 J82.

Keywords: COVID-19, informality, gender gap employment, Mexico, impulse response function.

Informalidad, brecha de género en el empleo y COVID-19 en México: identificando la persistencia y los efectos estructurales dinámicos

Resumen

El objetivo es analizar el impacto de la pandemia del COVID-19 en la dinámica del mercado laboral mexicano (empleo formal-informal) por género. Se construyen series de tiempo microfundamentales consistentes desde 1987:Q1 hasta 2019:Q4 utilizando las encuestas de empleo urbanas mexicanas, y se estima un modelo VAR que vincula la producción agregada y cada segmento del mercado. Nuestros resultados sugieren que hay efectos adversos significativos en el empleo formal como resultado de la pandemia del COVID-19, con una larga recuperación del empleo para las mujeres y los hombres. El sector informal, en ambos sexos, presenta una respuesta pronosticada menor al choque de producción inicial, pero pérdidas sustanciales de empleo observadas, potencialmente vinculadas a cambios estructurales en el mercado. En la crisis de COVID-19, el sector informal no es un sustituto de las pérdidas de empleo formal. La complejidad de esta crisis sugiere la elaboración de políticas que mejoren la facilidad del mercado para potenciar la recuperación del empleo formal al tiempo que se promueve la igualdad de género. Nuestra principal contribución es estimar las diversas pérdidas de empleo por segmentos y un cambio estructural crítico en la dinámica del mercado laboral resultante de la pandemia de COVID-19, centrando el análisis en el empleo urbano.

Clasificación JEL: E24, E26, J21 J82.

Palabras clave: COVID-19, informalidad, brecha de género en empleo, México, funciones impulso-respuesta.

[1] Corresponding author. Email: jorge.morenotr@uanl.edu.mx
* Investigación financiada por el Centro de Investigaciones Económicas de la Universidad Autónoma de Nuevo León, en el marco del 60 Aniversario de su fundación.

1. Introduction

On March 11th, 2020, the World Health Organization (WHO) declared the COVID-19 outbreak as a pandemic. Since then, more than 2 million deaths have been reported worldwide (Dong et al., 2020). In addition, more than 90 countries paralyzed most of their economic activities, including several production sectors, tourism, and essential services as education and other infrastructure investment. Moreover, significant concern about the pandemic has been understanding the structure and dynamics of this "exogenous shock" COVID-19 represented on productivity and employment.

For Mexico, the economic scenario has not been different from the rest of the countries. However, the results of the economic crisis reported at the end of 2019, coupled with the global pandemic trends, have traduced in more economic uncertainty and a halt in economic activities, resulting in more than half a million formal jobs lost (INEGI, 2020).

Analyzing employment in Mexico represents difficulties and specific challenges when compared to developed economies. For instance, labor informality in the last quarter of 2019 (pre-COVID-19 scenario) represented 56.2% of the economically active population (PEA)[2]. By gender for this same period, it was reported that 57.6% of women and 55.3% of men have informal employment. According to the above numbers, analyzing the structure of employment (formal and informal) and differentiating gender (men and women) is essential due to the heterogeneity between the groups. Understanding the underlying structure and analyzing it from this perspective contributes to a better understanding of this significant problem affecting our country.

This paper analyzes and identifies the deepening and persistence of the COVID-19 economic shock in the dynamics of the Mexican labor market. For this purpose, the labor market is divided into two main categories relevant to developing countries: formal and informal. Moreover, as other studies suggest (Moreno, 2007; Cuellar, 2019), the formality and informality segments present very different dynamics when analyzing male and female labor participation. Hence, in this paper, the labor market is also divided by gender, studying the dynamics of each segment.

A consistent micro-founded time series framework is constructed for the main employment variables. This approach is pursued by consistently defining and measuring all relevant dimensions directly from each micro data set on urban employment surveys in Mexico, using quarterly data from 1987:Q1 to 2019:Q4 and following the same urban areas throughout this period. First, a VAR model linking each employment class is defined and estimated (formal and informal, by gender) and aggregate production (defined by the real GDP) to identify the deepening and persistence of the initial shock of the recession. Then the structural impact is estimated when considering the pre-COVID-19 forecasting of employment dynamics, given the initial observed shock on productivity, and compare it with the actual levels of employment observed over the year 2020.

This work contributes to the economic literature in three areas. First, this paper uses consistent urban employment time-series steadily calculated directly from each available quarter of the Mexican employment surveys from 1987:Q1 to 2019:Q4, avoiding further conflicts or inconsistencies such as inclusion or exclusion of the sample cities. Second, besides the micro-founded

[2] Mexican National Institute of Statistics and Geography defines PEA as all persons aged 12 and over who, during the week of the survey, performed some type of economic activity or were part of the open unemployed population.

consistent methodology of the database construction for each variable time series, we estimate a dynamic employment model for both formal and informal sectors and by gender, identifying long-run structural differences in the dynamics of each market segment for the country through impulse-response functions. This approach compares previous evolution to the COVID-19 trends and identifies structural changes in the market once the effects of the initial shock on production are considered compared to the observed employment dynamics. Finally, our work estimates the recovery period for each defined segment of the labor market. In addition, however, it identifies long-run permanent effects derived from COVID-19 shock over the Mexican economy, particularly on the formal sector.

The paper is divided into five sections, including this introduction. The second section analyzes the stylized facts of the COVID-19 crisis on the Mexican macroeconomic context and its implications on employment. The third section presents the selected methodology to study employment dynamics by gender and employment formality; this section introduces the econometric framework, data, and empirical strategy to address our main questions. The fourth section presents the results obtained from the analysis. Finally, the fifth section concludes the study and presents the implications of the results.

2. The impact of COVID-19 on the Mexican economy: stylized facts

2.1 Taxonomy of economic "shocks."

The recurrent new waves of outbreaks worldwide over 2021 confirm that the COVID-19 economic crisis will have short- and long-term effects and severe economic repercussions worldwide.

According to the International Monetary Fund (2020), the projections are unfavorable for the economy, with a fall of -3% in 2020, and if the pandemic ceases, a global economic recovery could be expected in the middle of the year 2021, with a growth projection of 5.8%.

In Latin America and the Caribbean, the pandemic hit precisely in a recession, resulting in a negative economic impact of between 3 and 4% (CEPAL, 2020). Given that Mexico is one of the leading economies in Latin America, its projections are within these same ranges. The country's growth projection for Mexico is between 1.4 and 3% in 2021 (IMF, 2020), and such projections depend on the political decisions taken in the country and the efficient control of the spread of the virus. From the above estimations and described potential scenarios, it can be inferred that that the Mexican economic effects might present more profound structural effects, and this depends on its ability to cope and assimilate the effects of COVID-19 on the economy; some of these effects might be classified as short-run effects and others structural.

For this research, the impact of COVID-19 on the Mexican economy might come from two types of sources: "exogenous shocks" and what we call "structural effects."

The exogenous shocks in our country were observed at the end of the first quarter of 2020 when countries began implementing isolation measures. Given that Mexico is predominantly a tourism-dependent country, these external measures reflected Mexico's first shock in productivity (Esquivel, 2020). In addition to the isolation decisions taken in other countries, Mexico was forced to make decisions regarding this, and it was then that the policy of social distancing was proposed. This policy not only represented a measure to contain the virus but was also considered as part of the

exogenous shock. Once the exogenous shock impacts (COVID-19), there are implications in the economy that are usually "structural effects." Structural effects refer to the interrelationships of the different existing economic agents, which produce complex relationships, and these relationships bring with them different implications in the markets (Sampedro and Cortina, 1969). For Mexico, the structural effects derived from COVID-19 can be divided into three forms:

1. *Supply side – real effects*: the isolation brought the country's companies and industries to a standstill, and their supply chains and input production led to a reduction in aggregate supply.
2. *Demand side – real effects*: the social distancing and the contraction of the aggregate supply triggered an increase in unemployment in the country and decreased families' economic capacity, resulting in a reduction in the demand for goods and services in the economy.
3. *Financial risk – uncertainty effects*: due to the increase in external economic uncertainty, the Mexican economy experienced increases in interest rates, risk premiums, and Mexican Peso (currency) depreciation (Banco de México, 2020).

Identifying the sources of the economic impact will help us understand the repercussions that this impact will have on the markets, specifically for this study, and on the Mexican labor market.

2.2 Taxonomy of labor market "segments."

Employment in Mexico represents a significant issue in the country's economic structure, partly due to the "duality" faced by its labor market (Maloney 2004; Moreno 2007).

The term "dual market" refers to the existence of a market outside the formal labor market, what Hart (1970) called the "informal sector." This definition was generalized when the International Labor Organization (ILO), in 1972, analyzed economic activities in Kenya that were neither registered nor protected there.

Since then, labor informality is one of the most sensitive variables to measure, not only in Mexico but also in many other Latin American countries, since they face an informal sector of almost 60% (OECD, 2019), and the challenge of quantifying it lies not only in the estimates but also in achieving an unbiased definition of both the informal sector and informal employment. The following subsection details the definition used in this study.

Table 1. Mexican labor market segments, before and during COVID-19

	2019	2020	Difference
Men			
PEA	58.06	54.55	-3.51
Formal employment	34.63	35.16	-0.53
Informal employment	65.37	64.84	0.53

Women			
PEA	34.58	31.24	-3.34
Formal employment	35.49	39.93	-4.44
Informal employment	64.51	60.07	4.44

Source: Own estimation with ENOE data (2019 and 2020).
Notes: the values expressed in percentages. The data presented is for the third quarter of each year.

Table 1 presents data on the differentiated situation between employment structure and gender before and during the COVID-19 pandemic. In both genders, the economically active population (PEA) decreased by 3 to 4 percentage points (*pp*), with a more significant proportion for men. Concerning its structure, it can be observed that informal employment was more affected since there was a decrease of 0.53 pp for men and 4.44 pp for women, and these losses concern the PEA. According to Samaniego (2020), the phenomenon of contraction in informal employment had not occurred in previous crises since informality used to be an escape valve for the economy when formal employment was affected.

On the other hand, formal employment presents an increase in its proportion between 1 to 3 pp for both genders. This effect could be related to the third quarter of 2020 since some of the economic sectors were already operating, reflecting employment recoveries. This fact (adverse effect on employment) is presented in several studies that have focused on analyzing formal employment with social security data and report that the fall occurred from February to May 2020 (Esquivel, 2020; Samaniego, 2020; Ramirez, 2020), this inflection point has been cataloged as the most severe of the previous crises, surpassing by 5.7% the minimum point observed in the 2008-2009 crisis.

2.2.1 Formal and informal employment

For the case of Mexico, one of the most widely used definitions of formal employment is the one outlined in Article 123 of the Political Constitution of the United Mexican States, which mentions that formal workers are entitled to the benefit of contributory social security. According to Algazi (2018), there are two reasons why it is pertinent to stick to this definition. The first of them is a social reason because formal workers enjoy benefits against various risks, such as insurance for disability, death, dismissal, among other issues. These insurances allow the individual to evaluate his/her decision between employment into formality or informality categories. A second reason to define informality in these terms is related to labor productivity. In particular, those who belong to the informal sector are part of low-productivity companies, and, in turn, these laborers segment the market in such a way that formal and informal employment fluctuates according to economic cycles, and this is known as duality in the labor market (Maloney, 2004).

On the other hand, the Mexican National Institute of Statistics and Geography (INEGI), together with the Ministry of Labor and Social Welfare (STPS), establishes criteria to measure the informal sector using the National Survey of Microbusinesses (ENAMIN). These criteria include economic division, the number of workers, and excluding some areas of the formal sector's activity (Flores et al., 2005).

For this study, we adhere to both definitions. In salaried workers, it refers to whether the individual has social security (IMSS or ISSSTE).[3] In the case of employers, subcontractors, and self-employed workers, it is decided to opt for the number of workers employed (at least more than 15 people) and whether the company name is duly registered. Thus, for example, if an individual is a salaried employee but lacks social security, it is classified as informal employment. On the other hand, if the individual is an employer, subcontractor, or self-employed, and if he/she employs less than 15 people, he/she is also classified as informal employment. Finally, the agricultural sector is excluded from the sample, as recommended by previous literature.

2.2.2 Employment and the COVID-19 crisis in Mexico: previous findings

The importance of analyzing the impact of COVID-19 on employment lies in estimating how long it will take for the Mexican labor market to recover. Given that there is still no consensus on the possible causes and impacts on employment, the following is a set of papers divided into two types of analysis: one focused on differences in observed employment and the other on projections of job losses or recovery time.

From the first group of analyses, Meza and Hernandez (2020) studied the effects of COVID-19 on employment and poverty in the country, and they found that working poverty increased almost 16 percentage points from 2018 to 2020. As for formal employment between 2019 and 2020, a drop of almost one percentage point was presented, adding 0.5 points for July 2020. For the informal sector, a drop of 5.3 percentage points was also reported for July 2020. For its part, Mexico, Como Vamos (2020) reported a drop of 11.5% in the formal employment registered at the end of February 2020, with the southern states being the most affected.

Regarding the second group, Mendoza (2020) made projections of the PEA in the short term and estimates there is a possibility of recovery for the first quarter of 2021; in the model, he used a shock in the Global Index of Economic Activity (IGAE) and thus estimated the impact on the PEA. On the other hand, the Bank of Mexico (2020) predicted a loss of between 800 to 1.4 million jobs for 2020 and between 200 and 400 thousand formal jobs in 2021.

Nunez (2020) performed a simple exercise on employment, assuming that if the scenario remains as in 2019, a fall in employment of 3% would be expected, but if the trend is in European countries, a contraction in employment between 4.5 and 6% can be expected.

Altamirano et al. (2020) proposed three possible scenarios: short-term crisis, medium-term crisis, and prolonged recession. They estimated an analysis of the impact in terms of formal jobs lost. For Mexico, they estimated around -4.1% of jobs lost under the first scenario, -7.7% under a medium-term crisis, and, finally, -14.4% under a worst-case scenario.

Jiménez-Bandala et al. (2020) analyzed with data on mobility in workplaces and the rate of infection and found that a decrease in mobility reduces the rate of infection; however, in some places,

[3] Instituto Mexicano del Seguro Social or Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado.

this reduction did not occur, and this was because there was a high rate of informal employment in these places. On the other hand, Huesca et al. (2020) conducted an analysis focused on digital employment, using Markov chains, projecting that the proportion of digital employment will be 49% and unemployment will be 6% by 2021, as well as projecting an increase in labor informality as a result of this type of employment.

Based on the previous literature, various types of employment impact analysis but should be added that taking into account the structure of the Mexican labor market provides a better understanding of the subject. For this reason, the main contribution of our work is to make estimates, taking into account the heterogeneity of the labor market, which is why we differentiate between the structure of employment (formal and informal) and gender (men and women). Once the market is segmented, an analysis of the impact on employment is carried out, isolating the first COVID-19 shock (negative exogenous shock) from the "structural effects" produced by this crisis.

3. Data and methodology

3.1 Data

For the analysis, a homologation of two existing employment surveys carried out, the National Urban Employment Survey (ENEU) for the years 1987 to 2004 and the National Occupation and Employment Survey (ENOE) for the years 2005 to 2019. The bases were standardized to build aggregate data series from the micro-foundations of the labor market.

The INEGI publishes the ENEU and the ENOE to capture data on our country's employment and sociodemographic characteristics.

The surveys have the particularity of being a dynamic panel—that is, they follow an individual for five quarters and thus allow us to alternate each quarter to 20% of the sample. For the present research, we used the benefits of cross-sectional data to construct quarterly aggregate data (i.e., employment time series) because we are interested in obtaining the behavior in the aggregate of these series.

As a measure of production at the national level, we used the quarterly real gross domestic product (base 2013=1) from 1987 to 2019; this series is obtained directly from INEGI's statistical bank data. The GDP time series is used since we are interested in the demand for labor as a function of the aggregate production of this country.

Based on the above, and for this research, the construction of the time series is limited to the employment growth rates of individuals between the ages of 16 and 65 who are working and receiving a monetary payment greater than zero, thus excluding individuals who work without receiving any payment or remuneration.

The employment series was divided by gender and by structure[4]. The employment structure was divided according to the definition established in section 2.2.1.

For the analysis, six time series are constructed at the national level: male formal employment growth rate, female formal employment growth rate, male informal employment growth rate, female informal employment growth rate, GDP growth rate, and real hourly wage growth rate.

[4] See Annex 1.2 for the structure of employment time-series.

Finally, all rural areas are excluded from the country to homologate both databases since the ENEU only includes urban areas of Mexico.

3.2 Employment and production: a theoretical model with a neoclassical approach

The relationship between productivity and employment has been a relevant topic of study over the years. One of the most studied hypotheses is known as "Okun's Law," and this model measures the inverted relationship between unemployment and growth (Okun, 1962). Despite being a general reference framework, this model can identify structural changes in supply and demand; therefore, in this study, we refer to a neoclassical model proposed by Arrow et al. (1961), which studies the relationship between economic productivity and employment.

The model is based on the assumption of a perfectly competitive labor market where production is maximized by equating the technical marginal rate of substitution to real wages. On the other hand, the marginal product of labor can be derived from a CES-type production function and constant elasticity of substitution (Arrow et al., 1961; Akkemik, 2007). The CES production function is defined as follows:

$$Q = f(K, L) = \theta[\beta L^{-\rho} + (1-\beta)K^{-\rho}]^{\frac{s}{\rho}} \quad (1)$$

Where Q is the production, K is the capital factor, and L is the labor factor. β is a parameter that lies between zero and one, and it determines the distribution of income among the factors of production; θ measures technological progress, s measures the returns to scale, and ρ is the parameter that measures the elasticity of substitution between the factors of production (ρ>0). As mentioned above, optimality is reached when the marginal product of capital and labor equals their respective payments (the return to capital and the wage):

$$\frac{\partial Q}{\partial K} = f_k = r \ , \quad \frac{\partial Q}{\partial L} = f_L = w \quad (2)$$

From equation (2) and taking (1) as a base, the following expression is obtained:

$$\frac{\partial Q}{\partial L} = s\theta^{-\rho/s}(1-\beta)Q^{1+\rho/s}L^{-1-\rho} = w \quad (3)$$

Once equation (3) is found, logarithms are taken and rewrite the equation used for estimations:

$$\ln L = \alpha_0 + \alpha_1 \ln Q + \alpha_2 \ln w \quad (4)$$

The terms α_0, α_1 y α_2 represent the following:

$$\alpha_0 = \frac{1}{1+\rho}\ln(s\,(1-\beta)) - \frac{\rho}{1+s}\ln\theta\,,\ \ \alpha_1 = \frac{1+\rho/s}{1/(1+\rho)},\ \alpha_2 = -\frac{1}{1/(1+\rho)} \tag{5}$$

It can be observed that the expected effect of an increase in production is positive on employment and vice versa. This theoretical model will estimate the causal impact of the economy on employment in the following section.

3.3 Vector autoregressive (VAR) models

Given the nature of the theoretical model and the simultaneous interactions that productivity and employment variables represent, an unrestricted reduced-form vector autoregressive (VAR) econometric model is presented. If the VAR model is presented in the reduced form, the model equations' contemporaneous values are not represented as explanatory variables in the model. In addition, it should be noted that the lags of each variable in the east are the exogenous variables; on the other hand, the fact that the model is unrestricted means that each variable appears in each of the equations as explanatory variables.

The specification of this model is very useful when variables are simultaneously determined and helps us find persistence between variables in the long run (optimal specification of lags), and this is possible because no restrictions are imposed on the model, thus avoiding specification errors.

We start by defining our variables of interest represented in growth rates, with y_{1t} being the formal employment of men, y_{2t} the formal employment of women, y_{3t} men's informal employment, y_{4t} women's informal employment, y_{5t} real GDP, and, finally, y_{6t} the real hourly wage. Also, each vector has its respective autoregressive components and a vector of components associated with the white noise process, which is stationary and assumes a normal distribution. Another one of the characteristics associated with the specification of the empirical model is that all of its variables must comply with stationarity; these tests are detailed in the following section.

Thus, the reduced matrix version of the VAR can be represented in terms of its characteristic polynomials defined over the number of "L" lags, $a(L,\phi)$ y $b(L,\phi)$, as follows:

$$Y_t = \ a(L,\phi)\,Y_{t-1} + \ b(L,\theta)\varepsilon_t \tag{6}$$

$$a'(L,\phi)Y_t = \ b(L,\theta)\varepsilon_t \tag{7}$$

Given the time stability of the distribution of the series, it is possible to represent this process in terms of the Gaussian white noise process described in the following reduced form:

$$Y_t = \frac{b(L,\theta)}{a'(L,\phi)}\varepsilon_t = c(L,\phi,\theta)\varepsilon_t \tag{8}$$

In this case, the new characteristic polynomial $c(L,\phi,\theta)$ is unique for each VAR process defined over the number of lags (L). We used the maximum likelihood method via the properties of the Gaussian process to recover the set of parameters associated with the original model, $\{\phi,\theta\}$.

Finally, to know the optimal number of lags (L) in the estimation, we must perform a series of tests, which we present in the estimation and results section.

4. Estimation and results

This study analyzes the structure and dynamics of employment under the impact of the COVID-19 crisis in Mexico, differentiating these impacts between structure and gender. First, the structure and dynamics of employment are analyzed through a VAR model[5]. Once the dynamics are understood, the impact of this crisis is modeled, including a "negative shock" on productivity from impulse response functions. These functions gave us the partial loss of employment derived from the first exogenous COVID-19 shock, but to obtain the cumulative loss, we proceeded to project the long-term employment trends. The impulse response functions and employment trend estimates allowed us to differentiate what would have been without the pandemic. With the observed employment, the magnitude of the structural effects on employment can be captured. Finally, we presented recovery scenarios for each of the employment structures.

First, unit root tests are performed to confirm the statistical validity and stability[6] of the VAR model. We then present the VAR model, concentrating on exposing the differentiated effects on employment according to the structure and gender division, which helped us understand the dynamics. Finally, the analysis of employment derived from the first COVID-19 shock, and we presented its structural effects.

4.1 Unit root test

The variables used in the estimation are presented as growth rates, Augmented Dickey-Fuller (ADF), and Phillips-Perron unit root tests are performed to test their long-term stability.

Table 2 presents the stationarity tests for the growth rates of GDP, employment, and wages. It can be observed that, in both tests, all series are stationary, and, at the time, the variables are growth rates and were differenced once, so these series consist of order-one I(1) data.

Table 2. Z-statistics for hypothesis testing unit roots

Growth rates	Dickey-Fuller Augmented		Phillips-Perron	
PIB	-8.07	***	-77.68	***
Real wage per hour	-11.644	***	-139.52	***
Men				
Formal employment	-10.76	***	-120.76	***
Informal employment	-13.16	***	-146.52	***

[5] For estimation and forecasting, R studio software is used and for simulation of VAR models, see Ganrud et al. (2017).
[6] See Annex 1.1 for more statistical stability tests of the VAR model.

Women				
Formal employment	-12.60	***	-141.33	***
Informal employment	-12.74	***	-148.46	***

p-value: 0.01***, 0.05**, 0.10*.

Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE). Seasonally adjusted series presented by growth rates.

4.2 Employment structure and dynamics

The analysis uses an unrestricted VAR model, so one of the critical points to note is the order of the variables and the optimal number of lags for the model. Regarding the order of the variables in the VAR, there are several ordering techniques (variance decomposition and Cholesky factorization); in our study, we stuck to the theoretical model presented in section 3.2, which respects the following order of employment, GDP, and real wages.

Once the order was implemented, at least five selection criteria are used to estimate the model for the optimal choice of lags. Table 3 presents the statistics associated with the optimal selection.

As can be seen, in the study of the properties of the model, two groups of statisticians are proposing optimal lags: the first group (LL, LR, FPE, AIC) proposes that the number of lags should be 1, whereas the second group (HQIC, SBIC) proposes there should be 0 lags in the estimation.

In this research, we decided to integrate one lag in the estimation of the unrestricted VAR model, considering that four of the six tests show statistical consistency, and it is pointed out that the optimal number of lags is one.

Table 3. Selection criterion for optimal lags in VAR estimation

Lag	LL	LR	FPE	AIC	HQIC	SBIC
0	1808.18		1.90E-20	-28.3808	**-28.3262***	**-28.2465***
1	**1847.78**	**79.202**	**1.8E-20***	**-28.4375***	-28.4375	-27.4969
2	1866.86	38.148	2.40E-20	-28.171	-28.171	-26.4242
3	1886.93	40.143	3.10E-20	-27.9201	-27.9201	-25.3671
4	1914.17	54.479	3.60E-20	-27.7822	-27.7822	-24.4229

Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE). Seasonally adjusted series presented by growth.

Notes: Sample 127 observations. LL: log-likelihood, LR: likelihood ratio, FPE: final prediction error, AIC: Akaike's information criterion, HQIC: Hannan and Quinn information criterion, SBIC: Schwarz's Bayesian information criterion.

After selecting the specific criterion of the optimal lag selection in Table 4, the VAR model of interest on the impact on the different employment structures can be observed. Given the nature of the model and the high multicollinearity existing in it, it is not recommended to make individual inferences of the estimators. However, we can focus on the effects on the dependent variables of interest of each of the equations because it will support understanding the dynamics in employment when introducing the impact of COVID-19.

The VAR equations are presented in the order presented above. From the approach of this model, it is possible to observe the importance of the division of employment by structure and gender because there are differentiated effects between formal and informal employment and differences between genders.

In Table 4, the second and fourth columns pertain to the estimated equation for the formal employment of men and women, and it is observed that both genders react to changes in the economy. However, particularly for women, employment is more dynamic and interdependent to the different employment structures. In addition, there is a certain complementarity with men's employment (formal and informal); this effect could be contrary to what is expected in specific gender employment literature (Humphries, 1988) in which female employment has a substitution effect on male employment. On the other hand, some literature on human capital has supported complementarity in employment, given that men and women build a structure in the household where both complement each other, which is why the expected effect is positive (Becker, 1986). Finally, there is a dynamic for women and persistent adjustment in their long-term equilibrium (i.e., the behavior of formal employment adjusts to the same dynamics). In contrast, men only show complementarity with informal employment.

As for informal employment, its behavior does not react to economic changes. Again, this is true for both genders. In other words, evidence on this segment of the market suggests it is relatively inelastic to economic changes.

Table 4. VAR model: structure and dynamic on the Mexican labor market

	Men				**Women**			
Variable	Formal employment		Informal employment		Formal employment		Informal employment	
L1.emp.fm	0.0837		0.0904		0.481	**	0.0579	
L1.emp.fw	-0.0955		-0.0839		-0.43	**	-0.0703	
L1.emp.im	0.21	*	-0.0671		0.258	*	0.251	*
L1.emp.iw	-0.0697		0.00286		-0.176		-0.197	
L1.pib	0.605	***	0.083		0.507	*	-0.059	
L1.rwhr	0.0461		0.0142		0.00334		0.0000185	
Constant	0.0031		0.00715	**	0.00764	**	0.0121	***
N	130		130		130		130	
R-sq	0.1548		0.0133		0.1809		0.0403	
Chi2(prob)	0.001		0.948		0.0001		0.5227	

*p-value: 0.01***, 0.05**, 0.10**.*

Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE). Seasonally adjusted series presented by growth rates.

Once the dynamics and structure of employment have been analyzed, we can proceed to our sensitivity and impact analysis on the employment structure, emphasizing the "economic shock" of COVID-19 and the long-term trend.

4.3 Employment impact analysis: the COVID-19 shock and structural effect

In this section, we present the main contribution of this paper: to quantify and isolate the impact of COVID-19 and what we call the "structural effect" on employment in Mexico[7]. We rely on impulse response functions using productivity (GDP) as the impulse and response variables as the different employment structures by gender to estimate the impact. The observed change in Mexico's real GDP for the first quarter of 2020, which was -2.2 % (INEGI, 2020), is introduced as the initial shock of COVID-19. Figure 1 shows the impulse response functions differentiated by employment structure and gender. This figure shows the growth rate projections for the different employment segments once the I-shock COVID-19 was incorporated into the impulse response functions.

It can be observed that the shock in the short term (period t+1) is harmful to the formal employment of men and women in Mexico in both series, as estimated in several sources for IMSS-registered workers (Banxico, 2020). On the other hand, our estimate shows persistent employment loss throughout the five periods[8] and a more profound loss for women than men.

As for informal employment, an independent dynamic is observed in both genders, as mentioned in the dynamics of the model (Table 4), where informal employment seems to have self-determined behavioral dynamics (i.e., it is inelastic to economic shocks and only shows a persistence to its own series). This fact coincides with the findings of Huesca and Camberos (2009), who analyzed the counterfactual dynamics between the formal and informal markets for the years 1992-2001 in Mexico. These authors find that the informal sector presents relatively greater inequality than the formal sector due to the heterogeneity and higher dispersion of remunerations in this market.

These impulse response functions allow us to model the I-shock observed in Mexico derived from COVID-19 in the first quarter of 2020. These functions are taken as results in order to differentiate the first shock of the pandemic, and with the support of the estimates of the trend and employment observed in the four quarters of 2020, we can differentiate between the employment losses derived from the exogenous shock and the losses derived from the structural effects triggered by the COVID-19 crisis. Of course, only considering the initial economic shock of the pandemic may represent a limitation to this analysis. However, it allows us to quantify the magnitude of the COVID-19 I-shock represented in employment for Mexico.

4.3.1 Formal employment by gender

Formal employment, as discussed above, tends to be elastic to changes in the economy, so when there was an impact (I shock COVID-19) on formal employment, both men and women reacted.

Figures 2 and 3 show the cumulative loss of employment compared with its trend as an impact of the COVID-19 crisis for men and women, respectively. Three series can be distinguished from the graph. The first one, the black one, represents observed employment obtained from the ENOE for our sample. Only the second quarter of 2020 is calculated from the Telephone Occupation

[7] The projections are made in levels and the estimates are made in growth rates. For this reason, the graphs are smoothed, since they do not contain estimates of additional shocks to the natural trend of the long-run equilibrium shown in the time series.

[8] The declines observed in formal employment from the third period onwards should be taken with discretion, as the upper confidence interval shows small positive changes.

and Employment Survey. This study was an extension of the ENOE because the second quarter of the employment survey took place in seclusion. The red dotted line estimates the long-term growth trend and has been forecasted from our VAR model. Finally, the gray line is the estimate of the COVID-19 negative I-shock on employment, and this projection is calculated from the impulse response function (adding the negative GDP shock), and the long-run employment growth is added (Pre-COVID trend).

The loss in employment was deeper for women than men. In percentage terms, the minimum point of the drop in employment for men was in the third quarter of 2020, representing -8.35%, while it was -9.6% for women in the same period. This result coincides with the scenarios presented by the BID (2020); in particular, it is close to their projections of loss of formal employment in the medium-term scenario, in which they project a 7.7% drop in employment derived from a recession presented for more than three quarters, which is what is observed in this country.

In terms of the number of jobs lost at the inflection point, both genders accumulated a loss of around 1 million jobs. However, men accumulated losses of 597,814 formal jobs, whereas women accumulated losses of 475,289 formal jobs.

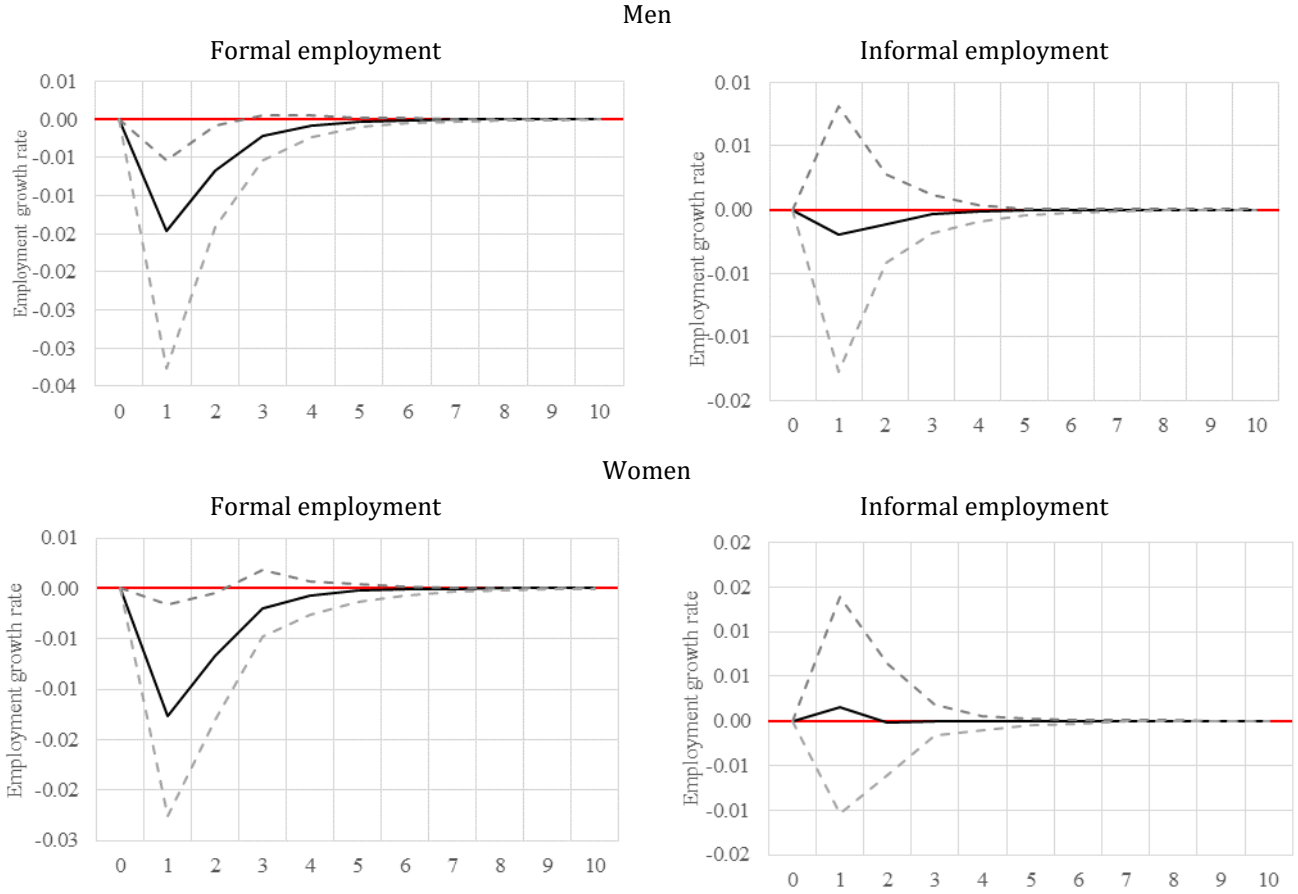

Figure 1. Impulse response function to negative shock in PIB related to COVID-19
Time set: quarters after initial COVID-19 production shock
Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE). Seasonally adjusted series presented by growth rates. Notes: confidence intervals 95%

Regarding the drop in employment, for men, only 1.21% represents the effect of the first COVID-19 shock, whereas 7.14% is the equivalent of the structural effect. Thus, in terms of employment, the first COVID-19 shock was equivalent to losses of 86,629, whereas the structural effect was the critical determinant of the losses, amounting to 511,185. On the other hand, of the 9.6% drop in women's employment, the first shock of COVID-19 was 0.7%, and 8.9% was the structural effect. Thus, the first shock is equivalent to 34,656 formal jobs in terms of jobs lost, and the structural effect is equivalent to losses of 440,633.

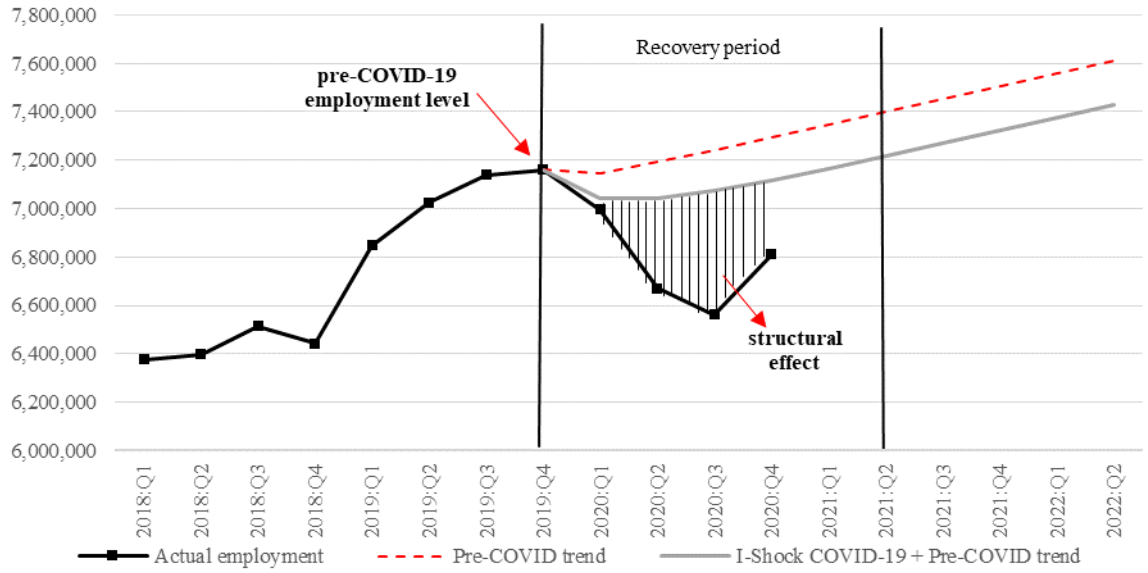

Figure 2. COVID-19 shock and structural effect on men's formal labor market

Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE).
Notes: trend estimation using the VAR model. The data of employment observed of second 2020 quarterly was calculated of ETOE.

From the above analysis, we conclude that the I-shock of COVID-19 was more significant for men relative to women. In contrast, the effect of the structural economy has a more significant impact on women's formal employment; this means that women's employment reacts more strongly to structural effects (92%, versus 86% for men), whereas men's employment reacts more strongly to exogenous shocks (14%, versus 7% for women).

For this reason, women's formal employment recovers faster than men's. As a result, the model forecasts that women will reach pre-COVID-19 employment levels one quarter earlier than men. Moreover, in the case of women, this recovery will begin to be observed in the first quarter of 2021, whereas that of men will be observed in the middle of the year (2021:Q2).

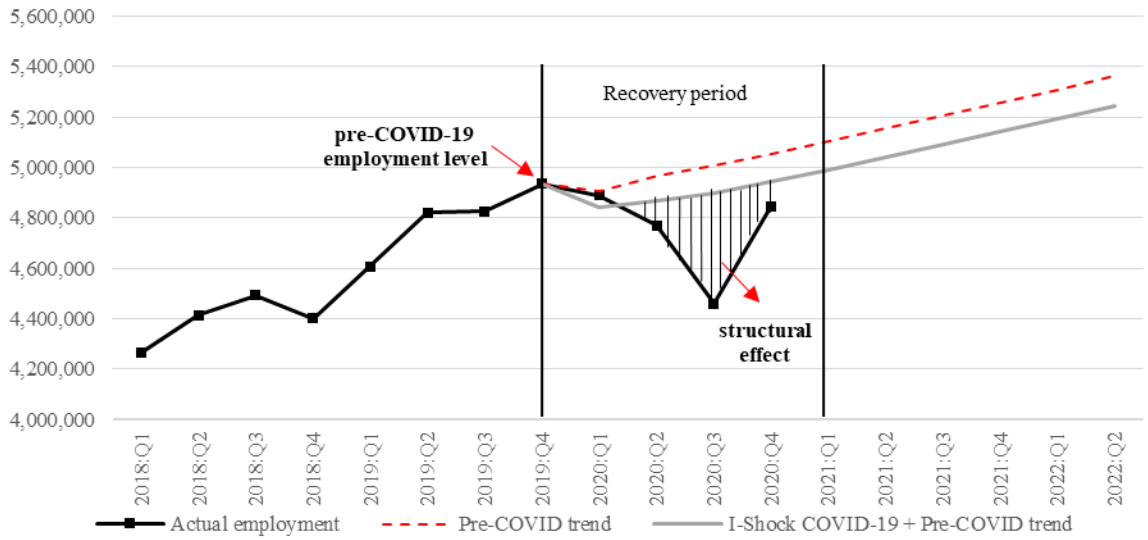

Figure 3. COVID-19 shock and structural effect on women's formal labor market
Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE).
Notes: trend estimation by VAR model. The data of employment observed of second 2020 quarterly was calculated of ETOE.

4.3.2 Informal employment by gender

Informal employment represents one of the most severe problems in our country; trying to quantify it gives us an approximation of the size of the problem. Estimates show that informal employment in both genders is inelastic to changes in productivity.

In Figure 4, particularly for men, the first quarter seemed to be an escape valve for job losses in the economy since the formal employment losses derived from the COVID-19 I-shock were around 163,700 jobs. In contrast, in the same period (2020:Q1), informal employment captured 115,074 jobs, almost equivalent to the losses. However, this increase was unsustainable because, by the second quarter of 2020, there was already a 43% drop in informal employment for men, as expressed by Samaniego (2020), who explained this is the most relevant decrease in informal employment of all time. In this sense, it is considered that this drop is entirely the result of the supply effect derived from the confinement because this phenomenon was observed in April, May, and June, and, as a consequence, many companies or businesses had to close and dismiss personnel; in particular, the tertiary or service sector was the most affected (Esquivel, 2020). This effect coincides with that reported by Altamirano et al. (2020), who reported that the tertiary sector has a higher proportion of informal employment in Latin America, such as social or communal services, commerce, restaurants, and hotels, so it can be concluded that, due to the effects of the confinement and closures, employment was affected for the first time in Mexico to this extent.

For women (Figure 5), the drop was almost the same magnitude as for men (-42.9%), which had an unexpected impact on this sector. Despite the substantial employment losses in both groups, it can be observed that employment began to recover for both groups from 2020:Q3 onwards.

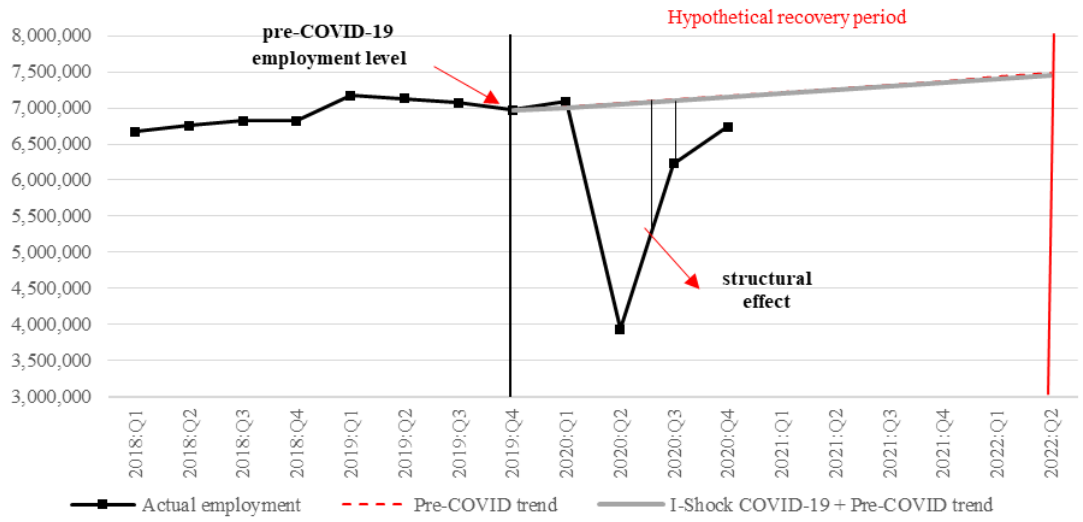

Figure 4. COVID-19 shock and structural effect on men's informal labor market
Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE).
Notes: trend estimation by VAR model. The data of employment observed of second 2020 quarterly was calculated of ETOE.

Concluding this section, to estimate a scenario of recovery in informal employment, another technique had to be considered because the model predicts with very little strength the fall in informal employment due to inelasticity in the face of economic changes. As an exercise, we apply the growth rates estimated with the impulse response functions plus the sum of the long-term trend and apply this growth rate to the last observation of observed employment (2020:Q4). For the male group, informal employment hypothetically began to recover by the beginning of 2022 (pre-COVID-19 employment level). On the other hand, by this same point (2022:Q1), women are expected to reach a level of employment approximate to the one observed at the end of 2018:Q4 (i.e., around 5 million jobs).

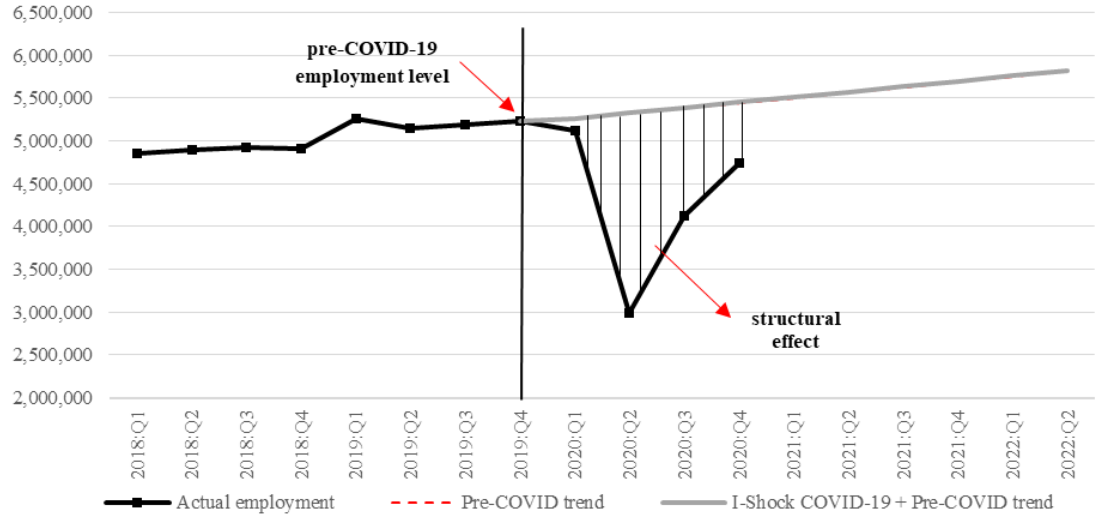

Figure 5. COVID-19 shock and structural effect on women's informal labor market
Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE).

Notes: trend estimation by VAR model. The data of employment observed of second 2020 quarterly was calculated of ETOE.

4.4 Pre-COVID-19 trends and the labor market recovery period: the case of formal employment

Finally, we performed a projection exercise on the recovery period of the formal labor market by focusing on the gap in permanent job losses as estimated by our model, using the latest available point data (2020:Q4) instead of the projections according to the COVID-19 initial shock.

Figure 6 shows an analysis of the formal labor market for men. The first point shows the pre-COVID-19 employment level, which was 7,159,142 in the fourth quarter of 2019. According to the projections of our VAR model, this employment level will recover in the middle of this year (7,217,580). Despite this recovery, there has been a gap in the permanent employment loss because, in that same period (2021:Q2), the pre-COVID-19 growth trend indicated there would be a level of 7,397,595 employed in our country. The difference between the pre-COVID-19 trends and the level of employment in 2021:Q2 is -2.5%. On the other hand, a growth trend at a constant rate (3.8%) was projected based on the last observation of current employment, which leads to the same conclusion as the VAR model. Therefore, the pre-COVID-19 employment level recovery is observed from 2021:Q2 if this growth rate prevails, but the gap of permanent employment loss would be less than 1%.

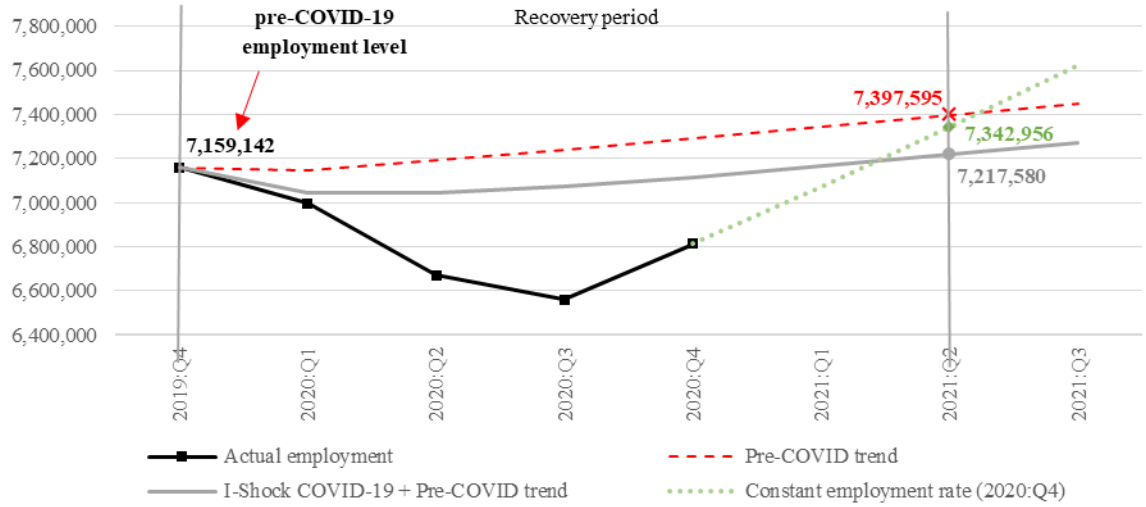

Figure 6. Men's formal employment recovery period: pre-COVID employment level vs. pre-COVID trend

Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE).
Notes: trend estimation by VAR model. The level of actual employment at the second 2020 quarterly was calculated with ETOE. The constant employment rate for 2020q4 was 3.8%.

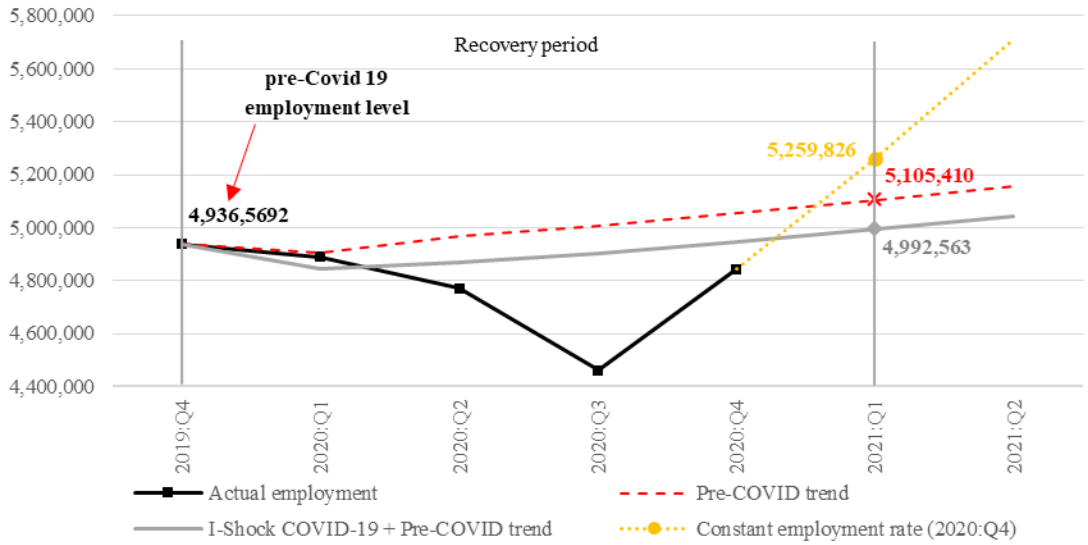

Figure 7. Women's formal employment recovery period: pre-COVID employment level vs. pre-COVID trend

Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE).
Notes: trend estimation by VAR model. The level of actual employment at the second 2020 quarterly was calculated with ETOE. The constant employment rate for 2020q4 was 8.5%.

On the other hand, the analysis of the female labor market (Figure 7) shows a different picture. The pre-COVID-19 employment level was 4,936,569 for 2019:Q4, so the econometric model projects a faster recovery than that of men since the employment recovery should be observed by the end of the first quarter of 2021. If the level of employment projected by the VAR model (4,992,563) has been reached, there would be a permanent employment loss of around -2.2%. However, if the constant growth trend rate (8.5%) is applied from the last observation of current employment, the gap of permanent employment losses would be reversed, and there would be an increase in women's formal employment of 3%.

5. Conclusions

This paper characterized the deepening and persistence of employment losses by gender and identified both formal and informal sectors. Using quarterly data from 1987 to 2019 and following the same urban areas for this period, a consistent micro-founded time-series framework is constructed for the primary employment variables by consistently defining and measuring all relevant dimensions directly from each micro data set urban employment surveys in Mexico.

An empirical model is constructed based on the neoclassical labor market theory. Although the Okun's Law hypothesis is a helpful framework, and there are studies showing the transitory correlation between unemployment and output in Mexico (Islas-Camargo et al., 2011; Alcaraz, 2009; Alcaraz et al., 2008; Chavarin, 2001), this approach does not allow us to identify or separate supply and demand effects. Hence, we decide to use the theoretical framework proposed by Arrow et al. (1961) as our primary reference.

Then, it is defined and estimated a VAR model linking each employment class (formal and informal, by gender) and aggregate production (defined by the real GDP) to identify the deepening and persistence of the initial shock of the recession. Then, we estimated the structural impact when considering the pre-COVID-19 forecasting of employment dynamics, given the initial observed shock on productivity, and compared it with the actual employment levels observed over the year 2020.
Our results show a significant structural and persistent effect on formal employment losses with lengthy recovery on employment levels, particularly in the formal male sector, as well as a larger relative recovery rate of female formal labor employment. On the other hand, both the female and male informal sectors show a lower initial long-run response to the COVID-19 shock, so all observed job losses are related to a structural change in the labor market. Thus, formal employment reacts to economic changes as it is more interdependent and dynamic in structure.

The implications of our analysis permit us to understand the deepening of the COVID-19 crisis in terms of changes in the market structure and how these changes induce larger impacts on the Mexican male formal and female formal labor markets. On the other hand, long-term estimations imply that all of the observed losses in informal employment could be related to profound structural changes in the labor market, as this market segment traditionally played the role of substitute of formality and buffer of real economic stress.

Given that the heterogeneity in human capital across cities induces different turnover and duration in workers' formality–informality cycle (Escobedo and Moreno, 2020), a critical concern of our work is related to the potential specific dynamics within each local urban market in terms of formality–informality dynamics. Therefore, further analysis beyond the purpose of this paper might be required to test the diversity of dynamic results across cities and their expanded urban areas within the country.

References

[1] Akkemik, K. (2007*). The response of employment to GDP growth in Turkey: an econometric estimation. Applied Econometrics and International Development*, *7*(1). 65-74.

[2] Alcaraz, C. (2009). Informal and formal labour flexibility in Mexico. *Revista Desarrollo y Sociedad*, (63), 115-143. https://doi.org/10.13043/dys.63.3

[3] Alcaraz, C., Chiquiar, D., y Ramos-Francia, M. (2008). *Diferenciales salariales intersectoriales y el cambio en la composición del empleo urbano de la economía mexicana en 2001-2004* (No. 2008-06). Working Papers. https://doi.org/10.36095/banxico/di.2008.06

[4] Alcaraz, C., y García, R. (2006). Cambios en la composición del empleo y evolución de la productividad del trabajo en el sector formal de la economía mexicana: 2000-2005. *Documentos de Investigación del Banco de México*, (2006-3). https://doi.org/10.36095/banxico/di.2006.03

[5] Algazi, S. (2018). *Esfuerzos mal recompensados: la elusiva búsqueda de la prosperidad en México.* Inter-American Development Bank.

[6] Altamirano, A., Azuara, O., & González, S. (2020). ¿Cómo impactará la COVID-19 al empleo? *Posibles escenarios para América Latina y el Caribe. Banco Interamericano de Desarrollo.* https://doi.org/10.18235/0002301

[7] Arrow, K., Chenery, H., Minhas, B., & Solow, R. (1961). Capital-Labor Substitution and Economic Efficiency. *The Review of Economics and Statistics*, *43*(3), 225. https://doi.org/10.2307/1927286

[8] Banco de México, B. D. M. (2020). Banco de México: Resumen Ejecutivo del Informe Trimestral enero-marzo 2020. Taken from: https://www.banxico.org.mx/publicaciones-y-prensa/informes-trimestrales/%7B27A91766-1C6C-467D-4361-5B8C46999D8F%7D.pdf.

[9] Becker, G. (1986). *An economic analysis of the family.* Economic and Social Research Institute.

[10] CEPAL, N. (2020). América Latina y el Caribe ante la pandemia del COVID-19: efectos económicos y sociales. https://doi.org/10.18356/9789210054720

[11] Chavarin, R. (2001). El costo del desempleo medido en producto: una revisión empírica de la ley de Okun para México. *El Trimestre Económico*, 209-231. https://doi.org/10.20430/ete.v78i309.31

[12] Cuellar, C. (2019). *Evolución de la brecha salarial en México: Un enfoque de género y capital humano para el sector formal asalariado* [Tesis de maestría no publicada]. Universidad Autónoma de Nuevo León.

[13] de Desarrollo, B. I. (2020). ¿Cómo impactará el COVID-19 al empleo? Posibles escenarios para América Latina y el Caribe. https://doi.org/10.18235/0002301

[14] Dong, E., Du, H., & Gardner, L. (2020). An interactive web-based dashboard to track COVID-19 in real time. *The Lancet infectious diseases*, *20*(5), 533-534. https://doi.org/10.1016/s1473-3099(20)30120-1

[15] Encuesta Nacional de Empleo Urbano (ENEU), años de 1987 a 2019, INEGI. Taken from: www.inegi.gob.mx

[16] Encuesta Nacional de Ocupación y Empleo (ENOE), años de 2005 a 2019, INEGI. Taken from: www.inegi.gob.mx

[17] Escobedo, J., & Moreno, J. (2020). Transición y persistencia en el ciclo formal-informal en México: El papel del capital humano. *Revista de Economía Laboral*, *17*(1), 1-45. http://doi.org/10.21114/rel.2020.01.01

[18] Esquivel, G. (2020). Los impactos económicos de la pandemia en México. *Economía UNAM*, *17*(51), 28-44. https://doi.org/10.22201/fe.24488143e.2020.51.543

[19] Flores, D., Valero, J., Chapa, J., & Bedoy, B. (2005). El sector informal en México: medición y cálculo para la recaudación potencial. *Ciencia UANL*, *8*(4).

[20] Gandrud, C., Williams, L., & Whitten, G. Dynamic Simulations of Autoregressive Relationships in R with dynsim. Taken from: https://www.semanticscholar.org/paper/Dynamic-Simulations-of-Autoregressive-Relationships-Gandrud-Williams/93faff473239bef8471e5f9be155acbe562b100c.

[21] Hart, K. (1970). 8. Small-scale entrepreneurs in Ghana and development planning. *The Journal of Development Studies*, *6*(4), 104-120. https://doi.org/10.1080/00220387008421338

[22] Huesca, L., Villarreal, C., Ochoa, G., & García, A. (2020). Efecto del COVID-19 en el empleo digital en México: un análisis con cadenas de Markov. *Panorama Económico*, *16*(32), 151-168. https://doi.org/10.29201/pe-ipn.v16i32.277

[23] Huesca, L., & Camberos, M. (2009). El mercado laboral mexicano 1992-2002. Un análisis contrafactual de los cambios en la informalidad. Economía Mexicana. Nueva Época, *XVIII*(1), 5-43.

[24] Humphries, J. (1988), "Women's employment in restructuring America: the Changing Experience of Women in Three Recessions," en Jill Rubery, (ed), Women and Recession Londres, Routledge and Kegan Paul, pp. 20-47.

[25] Instituto Nacional de estadística y Geografía, INEGI. (2020). Indicadores de ocupación y empleo. Cifras oportunas durante marzo de 2020.

[26] International Monetary Fund, IMF. (2020). World economic outlook: The great lockdown. *International Monetary Fund*. https://doi.org/10.5089/9781513539744.081

[27] Islas-Camargo, A., & Cortez, W. (2011). Revisiting Okun's law for Mexico: an analysis of the permanent and transitory components of unemployment and output.

[28] Jiménez-Bandala, C., Peralta, J., Sánchez, E., Olvera, I., & Aceves, D. (2020). La situación del mercado laboral en México antes y durante la COVID-19. *Revista Internacional de Salarios Dignos*, *2*(2). 1-14.

[29] Maloney, W. (2004). Informality revisited. *World Development*, *32*(7). 1159-1178. https://doi.org/10.1016/j.worlddev.2004.01.008

[30] Mendoza, J. (2020). COVID-19 y el empleo en México: impacto inicial y pronósticos de corto plazo. *Contaduría y administración*, *65*(4), 8. https://doi.org/10.22201/fca.24488410e.2020.3028

[31] Mexico, C. V. (2020). El impacto del COVID-19 sobre el empleo formal en los estados. Taken from: https://mexicocomovamos.mx/new/md-multimedia/1597177275-38.pdf.

[32] Meza, D., & Hernández, J. (2020). La crisis ocasionada por la COVID-19 y sus efectos en el empleo y la pobreza en México. *Revista Internacional de Salarios Dignos*, *2*(3). 23-38. https://doi.org/10.32719/25506641.2020.8.8

[33] Moreno, J. (2007). Are Formal and Informal Labor Market Wages Different? Analyzing the Gains and Losses from Formalization in México. *Ensayos*, *24*(1), 1-44.

[34] Nunez, R. (2020). Impacto del COVID-19 en el empleo en México: posibles escenarios y algunas recomendaciones de política económica. Taken from: https://www.udlap.mx/covid19/files/articulos/impacto-del-COVID-Roy-Herd-Nunez-UDLAP.pdf.

[35] OECD (2019). OECD Economic Surveys: Mexico 2019. https://doi.org/10.1787/a536d00e-en

[36] Okun, A. (1962). Potential GNP: Its Measurement and Significance. *In Proceedings of the Business and Economic Statistics Section of the American Statistical Association. Alexandria, VA. American Statistical Association*, 89-104.

[37] Producto Interno Bruto (PIB), años 1987 a 2019, INEGI. Taken from: https://www.inegi.org.mx/temas/pib/.

[38] Ramirez, T. (2020). Impactos del COVID-19 en el (des) empleo en México. Taken from: http://ru.crim.unam.mx/handle/123456789/56.

[39] Samaniego, N. (2020). El COVID-19 y el desplome del empleo en México/The COVID-19 and the Collapse of Employment in Mexico. *EconomíaUNAM*, *17*(51). 306-314. https://doi.org/10.22201/fe.24488143e.2020.51.566

[40] Sampedro, J., & Cortina, R. (1969). *Estructura economica: theoría basica y estructura mundial.* Ediciones Ariel.

Annex 1.1. Additional tests of validity and statistical stability of the VAR model

In addition to the unit root tests presented in section 4.1, stability roots, serial autocorrelation, and normality tests are performed. Table A1 presents the root stability test of the VAR model presented in section 4.2. It can be observed that all roots are less than 1, so this model satisfies the stability condition since these roots are within the unit circle.

Table A1. Stability root test

Variables	Root
PIB	.096376
Real wage per hour	.079002
Men	
Formal employment	.320032
Informal employment	.255753
Women	
Formal employment	.255753
Informal employment	.121917

Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE). VAR model with seasonally adjusted series presented by growth rates.

Other statistical validation tests for VAR models are the normality test (Jarque-Bera), skewness, and the kurtosis test. Table A2 shows one of the limitations of our work, which is that only female employment does not reject the null hypothesis (H0: Normality); the reason this test is not fulfilled for the other variables is due to the outliers and structural changes on the series.

Finally, Table A3 presents two tests of serial autocorrelation of the residuals (Portmanteau and Breusch-Godfrey tests), both of which do not reject the null hypothesis (H0: No autocorrelation of residuals), so the model complies with this test.

Table A2. Normality, skewness, and kurtosis tests

Variables	Jarque-Bera		Skewness		Kurtosis	
	Chi2	Prob>chi2	Chi2	Prob>chi2	Chi2	Prob>chi2
PIB	136.397	0.00000	18.947	0.00001	117.450	0.00000
Real wage per hour	8.866	0.01188	4.966	0.02585	3.900	0.04829
Men						
Formal employment	431.212	0.00000	10.246	0.00137	420.966	0.00000
Informal employment	17.196	0.00018	0.119	0.73064	17.077	0.00004
Women						
Formal employment	1.845	0.39755	1.599	0.20604	0.246	0.62003
Informal employment	2.577	0.27566	0.909	0.34037	1.668	0.19651
All	598.093	0.00000	36.785	0.00000	561.308	0.00000

Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE). VAR model with seasonally adjusted series presented by growth rates.

Table A3. Serial autocorrelation residual tests

Tests	Chi2	df	p-value
Portmanteu Multivariate	136.397	0.00000	18.947
Breusch-Godfrey	8.866	0.01188	4.966

Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE). VAR model with seasonally adjusted series presented by growth rates.

Annex 1.2. Structural employment in México 1987:Q1-2020:Q4

According to the methodology for obtaining the data sample, which is presented in section 3.1, the data structure is presented in Figure A1.

The four employment series show growth throughout the 31 years analyzed, but four aspects should be highlighted: 1) informal employment tends to be relatively higher than formal employment in both genders; 2) in the 1994-1995 crisis, a structural substitution effect between formal-informal employment is observed (Maloney, 2004; Moreno, 2007; Alcaraz and Garcia, 2006) as informal employment increases relatively while formal employment decreases in both genders; 3) a fall in both employment structures (formal-informal) is observed, which could be associated with the heterogeneity between these employment segments, since from 2001-2005 the international economic environment underwent substantial changes with the entry of China into the World Trade Organization (Alcaraz and García, 2006; Alcaraz et al., 2008) and, 4) the COVID-19 crisis represented the first drop in informal employment, a phenomenon that had never before been observed in Mexico's employment structure.

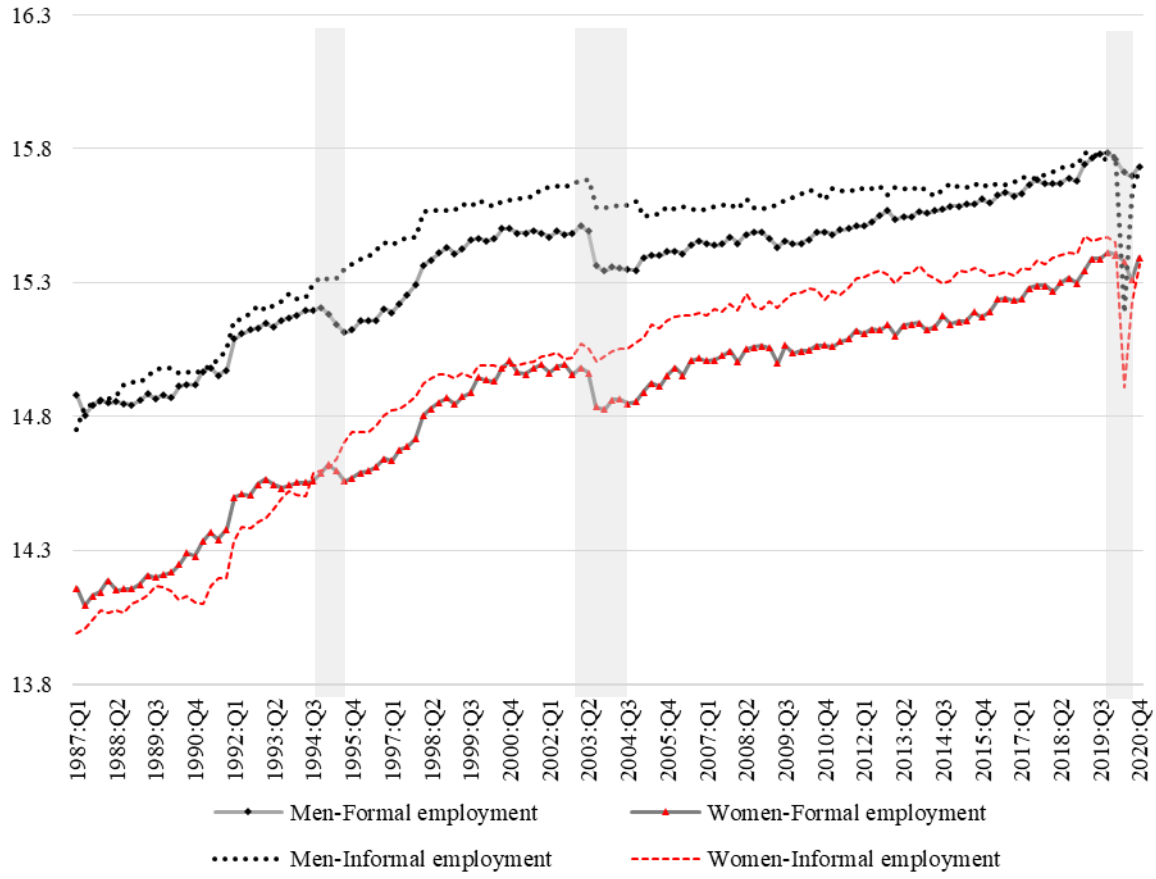

Figure A1. Structural employment in Mexico by gender, 1987:Q1-2020:Q4

Source: Own estimations with time series constructed and homologized of employment surveys (ENEU-ENOE).

Notes: The data of employment observed of second 2020 quarterly was calculated of ETOE.