

Illegal immigration in a dynamic economy with elastic labor supply and fiscal policies*

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Abstract

This paper explores the economic effects of illegal immigration in a dynamic general equilibrium model when the domestic labor supply is elastic and the fiscal policies include various taxes and income transfers. We show that, despite the mixed welfare effects of endogenous labor-leisure choices, illegal immigration improves the welfare of domestic households in the short- and long-run equilibrium allocation in a dynamic laissez-faire economy. We also show that the wage difference between domestic workers and illegal immigrant workers improves individual welfare but hurts aggregate output production. In addition, we explain how the fiscal policies generate a distortive wealth effect on a decentralized competitive equilibrium with illegal immigration. We show that the domestic household's welfare depends on the combination of the wage difference and the fiscal burden or drain from illegal immigrants under the various tax and income transfer policies. The fiscal burden often causes the opposite effect on individual welfare and aggregate performance in the presence of illegal immigration.

Keywords: illegal immigration;fiscal burden; income and payroll taxes; labor supply; wage; welfare

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1 Introduction

More than a dozen of cargo ships carrying illegal immigrants arrived in Europe between September 2014 and January 2015. European Migration Network (2015) reports that the total number

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of illegal immigrants entering the European Union increased by 159 percent to 276,000 in 2014. In the summer of 2016, German Chancellor Angela Merkel committed to take in 800,000 immigrants. Estimates in Clandestino (2009) reports that the European Union has about 1.9 million to 3.8 million unauthorized immigrants in 2008. In the United States, the total number of illegal immigrants has also risen rapidly from 3 million to 12 million over the last three decades (Passel and Cohn 2015) and the number of illegal immigrants accounts for approximately 4.9% of the 2007 U.S. employment. In many advanced countries, illegal immigration is not a new phenomenon, but the topic easily ignites divisive and controversial both academic and public debates. Many in the general public express their fear that illegal immigrants deprive citizens of domestic household jobs and increase government expenditure (Espenshade 1995; Hanson 2007). Nevertheless, illegal immigrants contribute to the domestic economy by consuming goods and services, providing cheap labor in production, and potentially paying taxes. The core of academic and public debates on the welfare effect of illegal immigration center on the labor market competition, fiscal burden, and the welfare of the domestic economy.

This paper investigates the effect of illegal immigration on the domestic economy by examining how illegal immigrants affect the behaviors of domestic households and producers in a dynamic laissez-faire economy. The paper also examines the governmental role of taxation and spending policies on the welfare of domestic households and illegal immigrants in a decentralized competitive economy.

Most previous studies on illegal immigration consider the welfare of domestic households in the presence of illegal immigrants in a static or dynamic laissez-faire economy. However, their critical assumption on the exogenous labor supply is so restrictive that we cannot address important issues on the individual agents' reactions to illegal immigration in the domestic labor market. Hence, their welfare analysis can be misleading because the labor-leisure choices of the domestic households as well as the input substitution in the production process are exogenous in a static or dynamic competitive economy. This paper allows the labor supply to be elastic so that we can account for the full effects of illegal immigration in the domestic labor market including domestic households' consumption and labor-leisure choices and the substitution between domestic labor and illegal immigrants and capital in the production. Hence, we expect that the former leads to a welfare effect for domestic households, and the latter influences the growth effect of the aggregate final output in the presence of illegal immigration.

A few recent studies in the literature extend their analysis of a dynamic social optimum economy (Hazari and Sgro 2003; Moy and Yip 2006) to a dynamic competitive economy (Palivos 2009; Palivos *et al.* 2011) with illegal immigration. In the same vein, we construct a dynamic competitive equilibrium model along with endogenous labor-leisure choices in the

presence of illegal immigration. Deviating from the existing analyses in the literature allows us to study an intertemporal mechanism of the current consumption and leisure versus savings and capital accumulation over periods. This dynamic analysis sheds light on a source of a controversy on how a domestic household's welfare is different from the level of aggregate equilibrium including the final output and economic growth in the presence of illegal immigration. This discrepancy between the domestic household's welfare and aggregate economic performance is not well recognized in the literature. Moreover, despite contentious public discussion, most earlier studies are not based on a theoretical model and abstract away from an analytic framework for illegal immigration policies in the literature. This paper attempts to fill this gap by introducing fiscal policies including taxation and income transfers in dynamic domestic markets. In particular, the paper provides a theoretical treatment of the effect of the fiscal burden or drain when illegal immigrants contribute a portion of government revenues in a decentralized competitive economy.

We build the presence of illegal immigration into a simple dynamic general equilibrium model with elastic labor supply and governmental fiscal policies.¹ In this dynamic laissez-faire economy, the production function exhibits a constant-returns-to-scale technology that combines the labor inputs domestic labors and illegal immigrants with capital stocks. The domestic household chooses consumption and leisure, rents out its capital stocks, and saves by accumulating capital. We also adopt several assumptions commonly used in the illegal immigration literature including [Palivos \(2009\)](#). First, an exogenous mass of illegal immigrants exists in the domestic labor market. Second, an illegal immigrant supplies labor inelastically, does not save for the future, and thus consumes all labor income and owns no capital. Third, the productivity of domestic workers is identical to that of illegal immigrants. Fourth, domestic workers and illegal immigrants are perfect substitutes in production.² Finally and most important, illegal immigrants are paid a lower wage than that of domestic workers. In addition to the usual models in the existing literature, we extend the dynamic laissez-faire economy to a decentralized competitive economy under fiscal policies. The fiscal policies include labor and capital taxes and income transfers to domestic households and/or illegal immigrants under balanced budget

¹Many economists, however, have paid attention to labor market competition and fiscal burden separately. Much research has been written about the effect of (legal and illegal) immigration on domestic employment and/or wage (e.g., [Borjas 2003](#); [Card 2001](#); [Ottaviano and Peri 2012](#)). Some research reports that illegal immigration is a net fiscal drain (taxes paid by illegal immigrants minus the costs they create) by showing the expected accounting estimates of net tax revenue in local, state or federal level (e.g., [Espenshade 1995](#); [Hanson 2007](#); [Congressional Budget Office 2007](#)).

²This assumption allows a flexible domestic labor market and thereby strengthening the main results in welfare analysis in this paper. [Palivos et al. \(2011\)](#) consider a degree of complementarity among skilled and unskilled workers and unskilled illegal immigrants but maintain the exogenous domestic labor supply.

constraints.

We highlight two salient features in our model. First, we introduce an elastic labor supply with illegal immigration in both a dynamic laissez-faire economy and a decentralized competitive economy with fiscal policies. An elastic labor supply plays a significant role in investigating the welfare effect of illegal immigration because domestic workers are most likely to adjust their labor supply in response to illegal immigrants in production. Second, exercising the analysis of fiscal policies is a new feature of the illegal immigration literature. It helps us to understand how domestic agents respond to various taxations and lump-sum income transfers in competitive domestic markets. Taxation captures the income and distortionary effect in domestic households and producers, and income transfers to illegal immigrants allows us to consider the issue of fiscal burden or drain on domestic households.³ Under balanced budget constraints, these features address the important issues of academic and public debates on the interaction between the labor supply decision and the fiscal burden, concerning domestic agents' optimal choices, which are affected by the presence of illegal immigration in the domestic economy.

Our main contributions are summarized as follows. First, we introduce a dynamic general equilibrium model that places three special economies in the literature. We establish the existence, uniqueness, and stability of a generalized competitive equilibrium. These properties allow us to parameterize and characterize each set of the short- and long-run equilibrium allocations. We decompose the effect of illegal immigration in the domestic labor market and thus compare our short- and long-run equilibrium with those in a dynamic laissez-faire economy with no illegal immigration (e.g., see [Turnovsky 2002](#)). In addition, our dynamic general equilibrium model incorporates an endogenous labor market and can pin down the full effect of the domestic labor market response to illegal immigration. As previously mentioned, the full response to illegal immigration generalizes the welfare analysis of a laissez-faire domestic economy in the literature (e.g., see [Polivos 2009](#)). For example, an elastic labor supply leads to labor-leisure choices in the domestic household's problem and thus generates an additional channel that affects the welfare of domestic households in the presence of illegal immigrants. Specifically, the elastic domestic labor supply increases the demand for leisure, but its substitution effect reduces consumption. Then, along with the positive welfare effect of a low wage for illegal immigrants in production, the net welfare effect of the elastic labor supply is ambiguous but nonetheless higher than one in the case with no illegal immigration in a dynamic

³[Hanson \(2007, fn 40\)](#) argues that illegal immigrants contribute to tax revenues. Illegal immigrants pay sales taxes on their purchases and property taxes on rental or own dwellings. They also contribute to the Social Security benefits and federal and state income taxes. As of 1986, U.S law requires all employers to record the Social Security number and visa information of immigrant employees, but many illegal immigrants present employers with invalid Social Security information.

laissez-faire economy.

Second, taking advantage of the analytic tractability of our dynamic general equilibrium model, the simple comparative dynamic analysis identifies some important properties of illegal immigration. For example, the wage difference between domestic workers and illegal immigrants results in an increase in individual consumption and aggregate consumption for domestic households but a decrease in aggregate output production. This result is due to the increase in the profits of and thus the dividend to domestic households. An increase in the domestic household's income leads to more consumption and leisure but less savings and labor supply, thereby causing more aggregate consumption but less aggregate output production. Hence, widening the wage differences improves individual welfare but worsens aggregate output production in a dynamic laissez-faire economy. On the other hand, we confirm that a high proportion of illegal immigrants in the domestic labor market increases individual consumption per domestic household as well as aggregate output production because the proportional increase in illegal immigrants does not completely offset the domestic labor supply in equilibrium.

Third, we extend the dynamic laissez-faire economy to a decentralized competitive economy with fiscal policies.⁴ The paper examines the role of fiscal policies on the welfare of domestic households and aggregate performance in a decentralized competitive economy. We show that the effects of income and capital taxes exceeds the expected effects of taxation in competitive economy with illegal immigration. However, the effect of the payroll tax is ambiguous on the welfare of the domestic economy because it leads to a decrease in consumption but to an increase in leisure per domestic household. Furthermore, we demonstrate the equivalence theorem in tax incidence of various taxes and income transfers so that the properties of illegal immigration are robust in a decentralized competitive economy. We then show that the equivalence theorem no longer prevails in the tax incidence of labor taxes in a domestic labor market. That is, the impact of the labor tax imposed on the demand for labor is not equal to that on the supply of the labor in the domestic labor market with illegal immigrants. This varying effect suggests that different statutory labor taxes generate different distortionary effects on the decentralized competitive equilibrium when illegal immigrants are present in the domestic labor market.

Finally, again under fiscal policies, we find that income transfers to illegal immigrants induce negative income effects as well as distortionary effects on the decentralized competi-

⁴Unlike our focus on illegal immigration policies, a few earlier studies consider policy effectiveness in a static economy with exogenous instruments such as a border control and employment sanctions (Ethier 1986a, 1986b; Bond and Chen 1987; Woodland and Yoshida 2006). Also, most dynamic models including Hazari and Sgro (2003) and Moy and Yip (2006) with exception of Palivos (2009) consider a social planning economy, which has no room for introducing any fiscal policy.

tive equilibrium.⁵ Fiscal burden reduces the steady state consumption and capital per domestic household and increases the labor supply in the domestic labor market. Intuitively, net income transfers affect the domestic household's income and capital accumulation and, in turn, change the consumption and labor supply of domestic households. An increase in the amount of income transfers to illegal immigrants causes both consumption and leisure to fall, thereby reducing the welfare of domestic households. In addition, we show that the net welfare of domestic households also depends on how much illegal immigrants contribute to government revenues. However, the net welfare effect does not depend on whether producers pay payroll taxes for illegal immigrants in production. On the other hand, this fiscal burden increases capital accumulation, along with the domestic labor supply, and thereby increases the aggregate output production in the domestic economy. Hence, the fiscal burden is another source for the conflicting effects between the domestic household's welfare and aggregate economic performance in a decentralized competitive economy in the presence of illegal immigration.

The remainder of the paper is organized as follows. Section 2 presents a dynamic *laissez-faire* economy with an elastic labor supply in the presence of illegal immigrants. The section also characterizes the short- and long-run equilibrium. Section 3 introduces fiscal policies and examines the effect of various tax schemes and income transfers to domestic households in a decentralized competitive economy. Section 4 investigates the fiscal burden on domestic households and discusses the welfare implications. Section 5 provides concluding remarks.

2 The dynamic *laissez-faire* economy

We introduce a dynamic general equilibrium model with illegal immigration. This dynamic *laissez-faire* economy consists of z number of domestic households, z^* number of illegal immigrants, and a representative producer. (From now on, an asterisk represents variables for illegal immigrants.) Each domestic household consumes, rents out its capitals, and accumulates capital. Each domestic household elastically supplies labor and thus the domestic labor market is endogenous. Each illegal immigrant also consumes and supplies labor but has no means to save and thus owns no capital. Each illegal immigrant inelastically supplies labor.⁶ The representative producer produces the final output by using domestic labor, illegal immigrants, and capital

⁵Although the federal law allows for the provision of both health care and education services regardless of the legal status of every immigrant, the Illegal Immigration Reform and Immigration Responsibility Act bars illegal immigrants from a few public services.

⁶Following earlier works (Moy and Yip 2006; Hazari and Sgro 2003), we abstract from illegal immigrants' economic decisions, for example, labor-leisure choice, savings, and capital accumulation in the competitive economy.

stocks. Both domestic households and illegal immigrants have an infinite life and are endowed with perfect foresight. All agents including the producer act competitively with no uncertainty. There is no depreciation on capital and no population growth.

2.1 Domestic household's and producer's problem

The representative domestic household maximizes intertemporal utility over time t , $t \in [0, \infty)$:

$$U = \int_0^{\infty} u(c(t), l(t)) e^{-\rho t} dt, \quad (1)$$

where $c(t)$ is consumption, $l(t)$ is working hours, and $\rho \in (0, \infty)$ is the time discount rate. We assume that the instantaneous utility function $u(c(t), l(t))$ is increasing in $c(t)$ and decreasing in $l(t)$, twice continuously differentiable, concave in $c(t)$ and $l(t)$, and satisfies a constant elasticity of intertemporal substitution and the Inada conditions. We specify that $u(c(t), l(t))$ is additively separable and logarithmic:

$$u(c(t), l(t)) = \ln c(t) + \theta \ln(1 - l(t)),$$

where $1 - l(t)$ is leisure with its weight $\theta \in [0, \infty)$ on instantaneous utility on leisure. Both intertemporal elasticity of substitution for consumption $c(t)$ and for labor supply $l(t)$ are 1.

Each household rents out capital $k(t)$ and receives the capital income $r(t)k(t)$, where $r(t)$ is the market rate of returns to capital. It also supplies $l(t)$ units of labor services, and the wage income is equal to $w(t)l(t)$, where $w(t)$ is the market wage rate. It also receives the net profit $\pi(t)$ from the ownership of producers. Hence, the household's budget constraints are

$$\dot{k}(t) = r(t)k(t) + w(t)l(t) + \pi(t) - c(t), \quad (2)$$

where the initial asset $k(0) = k_0$ is given and a dot over a variable denotes the time derivative.

Given the competitive market prices $r(t)$ and $w(t)$, the representative household maximizes the intertemporal utility (1) subject to the household's budget constraints (2). Hence, the first order conditions are, along with the feasibility conditions in (2),

$$\frac{\dot{c}(t)}{c(t)} = r(t) - \rho, \quad (3)$$

$$w(t) = \frac{\theta c(t)}{1 - l(t)}. \quad (4)$$

Then, the necessary and sufficient conditions for the domestic household's problem are (2)-(4) with the transversality condition

$$\lim_{t \rightarrow \infty} \frac{1}{c(t)} k(t) e^{-\rho t} = 0. \quad (5)$$

A solution to the household's problem exists and is unique under the assumptions on the utility function and the budget constraints.

The representative producer employs domestic workers z and illegal immigrants z^* in the dynamic laissez-faire economy. Each domestic household supplies $l(t)$ hours whereas each illegal immigrant supplies $l^*(t)$ hours in the domestic labor market. The aggregate working hours of domestic workers and illegal immigrants are $zl(t)$ and $z^*l^*(t)$, respectively. We assume that the domestic worker's and illegal immigrant's working hours are equally productive and, therefore, are perfect substitutes in production.⁷ We also assume that the production function exhibits the constant returns to scale in capital and labor. Furthermore, the representative producer takes the Cobb-Douglas production function, $Y(t) = [K(t)]^\alpha [zl(t) + z^*l^*(t)]^\beta$, where $K(t)$ is the aggregate capital stock and $zl(t) + z^*l^*(t)$ is the total labor input in production. In sum, given inelastic labor supply, $l^*(t) = 1$, by illegal immigrants, the production function $Y(t)$ is

$$Y(t) = [K(t)]^\alpha [zl(t) + z^*]^\beta, \quad (6)$$

where $\alpha, \beta \in (0, 1)$, $\alpha + \beta = 1$. Clearly, the production function is increasing, twice continuously differentiable, and concave in $K(t)$ and $zl(t) + z^*l^*(t)$.

Following from the literature on illegal immigration, we assume that, although they are equally productive, illegal immigrants are paid a lower wage than that of domestic workers.⁸ The degree of wage differences between domestic workers and illegal immigrants is measured by parameter $\mu \in (0, 1]$. Specifically,

$$w^*(t) = \mu w(t),$$

where $w(t)$ and $w^*(t)$ are the wage rate for domestic workers and illegal immigrants, respec-

⁷This perfect substitution assumption has no influence on our analysis and strengthens our main results on welfare analysis. See discussions in the following sections.

⁸This wage difference between the domestic and illegal immigrant workers partly justifies the inelastic demand for and supply of illegal immigration workers. Of course, many other factors such as a source country's wage rate and a detection rate in a receiving country determine the number of illegal immigrants (see, e.g., [Bandyopadhyay and Bandyopadhyay 1998](#); [Espenshade 1995](#); most recently, [Hanson 2006](#)).

tively.⁹ Once an equilibrium wage rate for domestic workers is determined in the competitive market, the wage rate for illegal immigrants is also determined by the μ difference. No wage difference exists when $\mu = 1$.

The representative producer maximizes its profit $\Pi(t)$ by taking factor prices $r(t)$, $w(t)$, and $w^*(t)$ as given,

$$\Pi(t) = Y(t) - r(t)K(t) - w(t)zl(t) - w^*(t)z^*. \quad (7)$$

Hence, the rate of returns to private capital and the wage rate for domestic workers are, respectively,

$$r(t) = \frac{\alpha Y(t)}{K(t)}, \quad (8)$$

$$w(t) = \frac{\beta Y(t)}{zl(t) + z^*}. \quad (9)$$

For further analysis, we denote $k(t) \equiv K(t)/z$ and $y(t) \equiv Y(t)/z$ as the capital stock and the final good per domestic household, respectively.¹⁰ First, the final output per domestic worker is written as

$$y(t) = [k(t)]^\alpha [\varphi + l(t)]^\beta, \quad (10)$$

where $\varphi \equiv z^*/z$ is the ratio of the number of illegal immigrants with respect to the number of domestic households. Then, (7) and (8) are written as $r(t) = \alpha y/k = \alpha k^{\alpha-1}(\varphi + l)^\beta$ and $w(t) = \beta y/(\varphi + l) = \beta k^\alpha(\varphi + l)^{\beta-1}$, respectively. (From now on we omit a time index unless it causes confusion.) The market rate of returns to capital $r(t)$ is equal to the marginal product of capital and the market wage rate $w(t)$ for domestic workers is equal to the marginal product of labor of domestic and illegal immigration workers. In addition, the marginal product of illegal immigration workers relative to domestic workers is 1 under the assumption that they have the same productivity. This relation partially justifies the exogenous demand for and supply of the illegal immigrants in the domestic labor market.

⁹This assumption is in line with the empirical evidences in [Rivera-Batiz \(1999\)](#) and [Borjas \(2005\)](#), who report that the wage rates for legal workers in the United States are statistically higher than those for illegal workers. However, we may endogenize this wage difference by introducing the notion that each labor supply has a different elasticity and a producer is able to set two wage rates separately in the domestic labor market.

¹⁰Unlike the normalization in this paper, several authors, including [Hazari and Sgro \(2003\)](#), [Moy and Yip \(2006\)](#), and [Palivos \(2009\)](#), define k as capital per workers including illegal immigrants and domestic households; that is, $k = K/(z + z^*)$. Later, we confirm that our normalization does not affect any of our main results.

2.2 Dynamic laissez-faire equilibrium with illegal immigrants

In this subsection we characterize the laissez-faire equilibrium with illegal immigrants. First, each household also receives capital income $rk = \alpha y$ from (7) and wage income $wl = \beta y - w\varphi$ from (8).¹¹ Second, we show that the representative producer enjoys positive profits Π due to exogenously supplied illegal immigrants z^* and the associated low wage rate $w^* = \mu w$.¹² To see this, substitute (7) and (8) into (6)

$$\Pi(t) = (1 - \mu)wz^* > 0. \quad (11)$$

The positive profit $\Pi(t)$ in (9) is distributed to domestic households as dividend, and thus each domestic household receives $\pi(t) \equiv \Pi/z = (1 - \mu)\varphi w$.¹³ Then, from (2), (3), (4), (7), (8) and (9), the domestic agent's optimal decisions are summarized as the system of dynamic equations for $\{c, k, l\}$ at each time period $t \in [0, \infty)$,

$$\frac{\dot{c}}{c} = \alpha k^{\alpha-1}(\varphi + l)^\beta - \rho, \quad (12)$$

$$\frac{\dot{k}}{k} = k^{\alpha-1}(\varphi + l)^\beta - \frac{c}{k} - \varphi[\mu\beta k^{\alpha-1}(\varphi + l)^{\beta-1}], \quad (13)$$

$$\frac{\theta c}{1-l} = \beta k^\alpha (\varphi + l)^{\beta-1}. \quad (14)$$

Finally, aggregating (11) over all domestic households leads to the aggregate resource constraints:

$$\dot{K}(t) = Y(t) - C(t) - \varphi \left[\frac{\mu\beta Y(t)}{\varphi + l(t)} \right], \quad (15)$$

where the last term on the right hand side of (13) is the total wage payments to illegal immigrants. Hence, the aggregate consumption for illegal immigrants is $C^*(t) = \varphi [\mu\beta Y/(\varphi + l)]$ and thus the consumption per illegal immigrant is $c^* = \frac{1}{z} [\mu\beta Y/(\varphi + l)]$. Notice that (13) generalizes

¹¹Alternatively, we can rewrite that the aggregate capital income is $rK = \alpha Y$ and the aggregate wage income is $wz = \beta Y - wz^*$ in the dynamic laissez-faire equilibrium.

¹²One may argue that the representative producer pays a fine to the government for hiring illegal immigrants so that the zero profit condition holds as long as the fine is equal to the profits from hiring illegal immigrants. When the fine is transferred to domestic households (see a similar argument in [Palivos 2009](#) and [Palivos et al. 2011](#)), our main results prevail in the present model.

¹³When subject to penalty for hiring illegal immigrants, a producer employs illegal immigrants only when it is compensated by potential profits. Hence, $\Pi(t)$ is viewed as a risk premium for illegal immigrants (see [Moy and Yip 2006](#), p. 2471).

the aggregate resource constraints; that is, no illegal immigration (i.e. $z^* = 0$ or $\varphi = 0$) implies the usual aggregate resource constraints: $\dot{K}(t) = Y(t) - C(t)$ as in the neoclassical growth model.

A dynamic competitive equilibrium exists when the dynamic allocation satisfies the following conditions: (i) Every agent optimizes his or her objective subject to feasibility constraints, (ii) all markets are clear, and (iii) the transversality condition holds given the initial capital stock. The following proposition summarizes the competitive equilibrium conditions in the presence of illegal immigrants.

Proposition 1. *Under the assumptions on technology and preferences with elastic domestic labor supply, the dynamic competitive equilibrium exists given the initial capital stock k_0 in a dynamic laissez-faire economy with domestic households z and illegal immigrants z^* if and only if the feasible allocation $c(t)$, $k(t)$, $l(t)$, $c^*(t)$, $C(t)$, and $Y(t)$ satisfies the dynamic equations (10)~(13) and the transversality condition, $\lim_{t \rightarrow \infty} \frac{1}{c(t)} k(t) e^{-\rho t} = 0$.*

This proposition depicts a competitive equilibrium in a dynamic laissez-faire economy in which domestic workers supply their labor endogenously and producers inelastically employ illegal immigrants as an input factor of production. This dynamic laissez-faire economy thus contains the three special economies in the economic growth literature with and without illegal immigration. The first special case is a dynamic competitive economy with no illegal immigrant (i.e., $\varphi = 0$) and with inelastic labor supply in domestic households (i.e., $\theta = 0$). Then, our dynamic laissez-faire economy degenerates to a standard neoclassic growth economy a la Solow (1956). This special case of the neoclassic growth economy captures the total effect of the illegal immigrants' labor supply and the endogenous domestic labor market. In the second special case that $\varphi \neq 0$ and $\theta = 0$, this economy represents a laissez-faire dynamic economy in the presence of illegal immigrants where a domestic household supplies labor inelastically and thus has no endogenous labor-leisure choice in a domestic labor market. In contrast to the literature on illegal immigration, for example, Palivos (2009) and many others, this special case captures the effect of elasticity of domestic labor supply in the presence of illegal immigrants. In the third special case, the dynamic laissez-faire economy represents a neoclassical competitive economy with elastic labor supply (i.e., $\theta \neq 0$) but no illegal immigrant (i.e., $\varphi = 0$) as in Turnovsky (2002). This special case separates the effect of illegal immigrants from the endogenous domestic labor market in the neoclassical growth economy. For the dynamic comparative analysis in the next subsection, we examine the properties of the dynamic competitive equilibrium by comparing each corresponding equilibrium in the three special economies.

2.3 Steady state competitive equilibrium

Before analyzing a transitional dynamic path, we focus on the long-run competitive equilibrium with illegal immigration in the dynamic laissez-faire economy. In the steady state, we define that $\dot{c}(t) = 0$, $\dot{k}(t) = 0$, and $\dot{l}(t) = 0$. Hence, the consumption $\bar{c}(t)$, capital $\bar{k}(t)$, and working hours for the domestic household $\bar{l}(t)$, along with the consumption $\bar{c}^*(t)$ per illegal immigrant, are also constant in the steady state. In addition, the aggregate domestic consumption $\bar{C}(t)$ and final output $\bar{Y}(t)$ are also constant in the steady state. Therefore, from (10)~(13), the steady state equilibrium $\{\bar{c}, \bar{k}, \bar{l}, \bar{c}^*, \bar{C}, \bar{Y}\}$ satisfies the system of the equations as

$$\bar{c} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left\{ \frac{\beta[1 + \varphi(1 - \beta\mu)]}{\beta + \theta} \right\}, \quad (16)$$

$$\bar{k} = \left(\frac{\alpha}{\rho}\right)^{\frac{1}{1-\alpha}} \left\{ \frac{\beta[1 + \varphi(1 + \theta\mu)]}{\beta + \theta} \right\}, \quad (17)$$

$$\bar{l} = \frac{\beta - \theta\varphi(1 - \beta\mu)}{\beta + \theta}, \quad (18)$$

$$\bar{c}^* = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left[\frac{\mu\beta}{\varphi + l} \right] \left\{ \varphi + \left[\frac{\beta - \varphi\theta(1 - \beta\mu)}{\beta + \theta} \right] \right\}, \quad (19)$$

$$\bar{C} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left\{ \frac{\beta z [1 + \varphi(1 - \beta\mu)]}{\beta + \theta} \right\}, \quad (20)$$

$$\bar{Y} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left\{ \varphi z + z \left[\frac{\beta - \varphi\theta(1 - \beta\mu)}{\beta + \theta} \right] \right\}. \quad (21)$$

The steady state equilibrium with illegal immigrants is completely characterized in terms of the parameter values in the fundamentals and thus is generically unique in a competitive laissez-faire economy. The presence of illegal immigration clearly affects the steady state equilibrium such as consumption in (14), capital stocks in (15), domestic worker's labor supply in (16), illegal immigrant's consumption in (17), aggregate domestic consumption in (18), and final output in (19).¹⁴

Now we are ready to investigate how the presence of illegal immigration affects the welfare of domestic households. For the welfare analysis of the presence of illegal immigrants in a dynamic laissez-faire economy, we compare the steady state equilibrium $\{\bar{c}, \bar{k}, \bar{l}\}$ in (14)-(19)

¹⁴From (16), the steady state domestic household's leisure $1 - \bar{l} = \frac{\theta}{\beta + \theta} [1 + \varphi(1 - \beta\mu)]$ in the long run. Hence, the domestic labor supply should be larger than zero but less than or equal to 1: $0 < \beta - \theta\varphi(1 - \beta\mu) \leq 0$.

with the steady state equilibrium $\{\bar{c}_{\varphi=0}, \bar{k}_{\varphi=0}, \bar{l}_{\varphi=0}\}$ with no illegal immigration. Recall that this economy is the third special case with $\varphi = 0$ as in [Turnovsky \(2002\)](#). This comparison provides the robustness of a positive welfare effect for the presence of illegal immigrants at the endogenous domestic labor market in a dynamic laissez-faire economy. The result is summarized in the following lemma.

Lemma 1. *Under the conditions in Proposition 1, the presence of illegal immigration increases the steady state equilibrium consumption \bar{c} in (14) and capital \bar{k} in (15) but decreases the steady state labor supply \bar{l} in (16) in a dynamic laissez-faire economy with an elastic labor supply.*

Proof. When $\varphi = 0$, the competitive economy has no illegal immigrants. With $\varphi = 0$ from (14)~(16), we find the steady state allocation for consumption $\bar{c}_{\varphi=0} = (\alpha/\rho)^{\alpha/\beta} \beta/(\beta + \theta)$, capital stocks $\bar{k}_{\varphi=0} = (\alpha/\rho)^{1/\beta} \beta/(\beta + \theta)$, and working hours $\bar{l}_{\varphi=0} = \beta/(\beta + \theta)$. Therefore, we have that $\bar{c}/\bar{c}_{\varphi=0} = 1 + \varphi(1 - \beta\mu) > 1$, $\bar{k}/\bar{k}_{\varphi=0} = 1 + \varphi(1 + \theta\mu) > 1$, and $\bar{l}/\bar{l}_{\varphi=0} < 1$. \square

We now investigate how the elastic labor supply in the domestic labor market affects the competitive equilibrium in the presence of illegal immigrants. To do so, the steady state equilibrium is compared with one in the second special case with $\theta = 0$ that the labor supply in the domestic market is inelastic as in [Palivos \(2009\)](#). Introducing the elastic labor supply not only generalizes the effect of illegal immigrants' labor supply in the domestic labor market but also enriches the dynamics of the consumption, leisure, and saving decisions of the domestic households. The following lemma summarizes the effect of the endogenous domestic labor market in the presence of illegal immigrants.

Lemma 2. *Under the conditions in Proposition 1, the steady state consumption \bar{c} in (14) and capital \bar{k} in (15) in a dynamic laissez-faire economy with an elastic labor supply in (16) are lower than those in a dynamic laissez-faire economy with an inelastic labor supply.*

Proof. In the second special case, the steady state equilibrium $\{\bar{c}_{\theta=0}, \bar{k}_{\theta=0}, \bar{l}_{\theta=0}\}$ is obtained by setting $\theta = 0$ in (14)-(16). Therefore, along with inelastic domestic labor supply, $\bar{l}_{\theta=0} = 1$, we have the steady state allocation for consumption $\bar{c}_{\theta=0} = (\alpha/\rho)^{\alpha/\beta} [1 + \varphi(1 - \beta\mu)]$ and capital stocks $\bar{k}_{\theta=0} = (\alpha/\rho)^{1/\beta} [1 + \varphi(1 + \theta\mu)]$. Again, by using (14)-(16), we conclude that $\bar{c}/\bar{c}_{\theta=0} = \beta/(\beta + \theta) < 1$ and $\bar{k}/\bar{k}_{\theta=0} = \beta/(\beta + \theta) < 1$. \square

The following corollary now concludes the welfare implications in the presence of illegal immigrants.

Corollary 1. *Under the conditions of Proposition 1, illegal immigration increases the*

domestic household's steady state consumption, $\bar{c} > \bar{c}_{\varphi=0}$, and leisure, $1 - \bar{l} > 1 - \bar{l}_{\varphi=0}$, in the long run, thereby increasing the steady state welfare in a dynamic laissez-faire economy with an elastic labor supply. However, because the elastic labor supply reduces the steady state welfare from the steady state consumption, $\bar{c} < \bar{c}_{\theta=0}$ and increases steady welfare from steady state leisure, $1 - \bar{l} > 1 - \bar{l}_{\theta=0}$, the net welfare effect of the elastic labor supply is ambiguous in the presence of illegal immigration.

Proof. Immediately from the previous discussions including the properties in Lemmas 1 and 2. \square

Lemmas 1 and 2 and Corollary 1 provide important welfare implications. Suppose the standard neoclassical growth economy a la Solow, where no illegal immigration exists and the domestic labor supply is perfectly inelastic. This economy is the first special case that $\varphi = 0$ and $\theta = 0$. The domestic household consumes $\bar{c}_{\varphi=0, \theta=0}$, rents out $\bar{k}_{\varphi=0, \theta=0}$, and supplies labor inelastically. First, the producer yields no positive profit (see (9)) and the domestic household receives no dividend from the ownership of production. Then, from (14)-(16), we have $\bar{c}_{\varphi=0, \theta=0} = (\alpha/\rho)^{\alpha/\beta}$ and $\bar{k}_{\varphi=0, \theta=0} = (\alpha/\rho)^{1/\beta}$ with $\bar{l}_{\varphi=0, \theta=0} = 1$. Now, illegal immigrants are introduced in this neoclassical growth economy. This economy is the third case that $\varphi \neq 0$ and $\theta = 0$. The representative producer begins to hire illegal immigrants because their wage rate is lower than that of domestic workers even though both domestic and illegal immigration workers have the same productivity. The hiring of illegal immigrants generates positive profits to the producer (again, see (9)), and each domestic household receives dividends from its ownership of production (see footnote 12). The dividends increase the domestic household's income, which causes the domestic household to increase consumption as well as savings in the form of capital. An increase in the aggregate capital stock stimulates the final output production in the competitive economy. Due to the diminishing marginal utility and decreasing marginal product of capital (see the stability property of the steady state in the next subsection), the dynamic competitive equilibrium converges to a new steady state allocation with a higher consumption $\bar{c}_{\theta=0}$ and a higher capital level, $\bar{k}_{\theta=0}$. That is, as shown in Lemma 2, $\bar{c}_{\varphi=0, \theta=0} < \bar{c}_{\theta=0}$ and $\bar{k}_{\varphi=0, \theta=0} < \bar{k}_{\theta=0}$.

This analysis is well known in the literature, including [Hazari and Sgro \(2003\)](#) and [Moy and Yip \(2006\)](#) who emphasizes this channel for the positive welfare effect of illegal immigrants in a dynamic growth economy. This analysis, however, ignores the important mechanism of the domestic labor market's response to the supply of illegal immigrants. In our dynamic laissez-faire economy, the elastic labor supply of the domestic households permits the interaction between the domestic labor supply and illegal immigrants, completing the dynamics of

the competitive equilibrium in the presence of illegal immigrants in the domestic labor market. Hence, the present model incorporates the additional mechanism from endogenous leisure-labor choices of the domestic households. When the labor supply of domestic households is elastic and the domestic labor market is endogenous (see Lemma 1), each domestic household adjusts not only its labor-leisure choices but also its consumption, savings, and capital accumulation over periods. In fact, we show that the long-run consumption and capital stocks of the domestic household is lower than those in the second special case that $\theta = 0$ where the domestic households inelastically supply their working hours. Even though the domestic households enjoy leisure, the effect of the elastic labor supply is negative on long-run consumption and capital accumulation in a competitive economy with illegal immigration. However, as shown in Corollary 1, this negative effect from labor adjustment is smaller – although the domestic households’ and illegal immigrants’ working hours are perfect substitutes – than the overall positive welfare effect from illegal immigration, and thus the net welfare effect is positive in the presence of illegal immigrants in the domestic labor market.¹⁵

<Add discussion on illegal immigrants’ consumption>

Thus far we have studied the effect of illegal immigrants on the individual agent’s allocations in the dynamic laissez-faire economy. We now examine the effect of illegal immigration on the aggregate competitive equilibrium.¹⁶ Thus, the following corollary is immediate from the steady state aggregate equilibrium.

Corollary 2. *Under the conditions of Proposition 1, illegal immigration increases steady state aggregate final output \bar{Y} and aggregate domestic consumption \bar{C} in a dynamic laissez-faire economy with an elastic labor supply. Furthermore, the elastic labor supply in the domestic labor market reduces steady state aggregate final output \bar{Y} and aggregate consumption \bar{C} in the presence of illegal immigrants in a dynamic laissez-faire economy.*

Proof. Recall that $\varphi = 0$ represents an economy without illegal immigrant so that the first part is immediate from (18) and (19) so that $\bar{Y}_{\varphi=0} < \bar{Y}$ and $\bar{C}_{\varphi=0} < \bar{C}$. On the other hand, also recall that $\theta = 0$ represents an economy without an elastic labor supply so that the second part

¹⁵(consider to delete this footnote) We then summarize the level of consumption, capital, and labor supply of domestic households among the four different economies including our generalized economy as in Lemmas 1 and 2 as follows. For the steady state consumption \bar{c} per domestic household, the case must be that $\bar{c}_{\varphi=0} < \bar{c}_{\varphi=0, \theta=0} < \bar{c} < \bar{c}_{\theta=0}$. For the steady state capital stocks \bar{k} per domestic household, $\bar{k}_{\varphi=0} < \bar{k}_{\varphi=0, \theta=0} < \bar{k} < \bar{k}_{\theta=0}$. For the steady state labor supply \bar{l} of a domestic household, $\bar{l} < \bar{l}_{\varphi=0} < \bar{l}_{\theta=0} = \bar{l}_{\varphi=0, \theta=0} = 1$. These inequalities display the effects of illegal immigration in an elastic domestic labor market.

¹⁶<from text, consider to delete> After the simple but tedious algebra, we show that, from (17), $\bar{C}_{\varphi=0} < \bar{C}_{\varphi=0, \theta=0} < \bar{C} < \bar{C}_{\theta=0}$ for the aggregate domestic consumption in the steady state. Similarly, from (18), we have that $\bar{Y}_{\varphi=0} < \bar{Y}_{\varphi=0, \theta=0} < \bar{Y} < \bar{Y}_{\theta=0}$ for the aggregate final output in the long run.

is from (17) and (18) so that $\bar{Y} < \bar{Y}_{\theta=0}$ and $\bar{C} < \bar{C}_{\theta=0}$. \square

The welfare analysis in the previous corollary is consistent with prior studies of dynamic social optimum and competitive economies with illegal immigrants (e.g., [Hazari and Sgro 2003](#); [Palivos 2009](#)). The steady state aggregate consumption and final output in the benchmark laissez-faire economy with illegal immigration are higher than those aggregate variables in a dynamic competitive economy without illegal immigration. However, when the domestic household's labor supply is inelastic, the long-run aggregate consumption and final output is most likely overestimated with respect to the corresponding aggregate consumption and final output in a dynamic competitive economy with an elastic labor supply.

2.4 Local stability and comparative dynamic analysis

In this subsection, we further characterize the steady state of the dynamic equilibrium with illegal immigration. We begin by establishing the local dynamic stability of the steady state equilibrium and then conduct a comparative dynamic analysis of the size of illegal immigrants and the wage difference between a domestic household and an illegal immigrant. Given the nonlinear dynamic equations in (10)-(12), we linearize them around the steady state $(\bar{c}, \bar{k}, \bar{l})$ in (14)-(16). Then, we have the following system of the linear equations:

$$\begin{bmatrix} \dot{c} \\ \dot{k} \end{bmatrix} = \begin{bmatrix} -\theta \left(\alpha \frac{\bar{c}}{\bar{k}} \right) \Omega & -\left(\alpha \frac{\bar{c}}{\bar{k}} \right) \left(\beta \frac{\bar{y}}{\bar{k}} \right) \Omega \\ -1 - \theta \left(\frac{\bar{l} + \varphi(1 + \alpha\mu)}{\varphi + \bar{l}} \right) \Omega & \frac{\bar{c}}{\bar{k}} - \left(\beta \frac{\bar{y}}{\bar{k}} \right) \left[\Omega - \varphi(1 - \alpha\Omega) \left(\frac{\mu}{\varphi + \bar{l}} \right) \right] \end{bmatrix} \begin{bmatrix} c - \bar{c} \\ k - \bar{k} \end{bmatrix}, \quad (22)$$

where $\bar{y} = \bar{k}^\alpha (\varphi + \bar{l})^\beta$, $\Omega = (\varphi + \bar{l}) / (\alpha + \varphi + \beta\bar{l}) \in (0, 1]$.

For the saddle stability for the steady state equilibrium, it suffices to show that the real values of the two eigenvalues of the Jacobian matrix J in (21) have the opposite sign. First, the determinant of the Jacobian matrix J is

$$\det J = - \left(\alpha \frac{\bar{c}}{\bar{k}} \right) \left[\theta \frac{\bar{c}}{\bar{k}} + \left(\beta \frac{\bar{y}}{\bar{k}} \right) \left[1 + \frac{\varphi\mu\theta}{\varphi + \bar{l}} \right] \right] \Omega.$$

Then, clearly $\det J < 0$, and thus one eigenvalue is positive, and the other eigenvalue is negative. Therefore, the steady state equilibrium is saddle stable. It is summarized in the following proposition.

Proposition 2. *Under the conditions of Proposition 1, the unique steady state $\{\bar{c}, \bar{k}, \bar{l}\}$ in (14)-(16) is saddle stable, and the transitional path $\{c, k, l\}$ in (10)-(12) is unique from the*

initial condition k_0 in a dynamic *laissez-faire* economy with illegal immigration.

This proposition generalizes the saddle stability property for economies with no illegal immigration and/or inelastic domestic labor supply. First, when illegal immigrants are absent (i.e., $\varphi = 0$), the associated determinant of J is $-\bar{l}/(\alpha + \beta\bar{l})[\alpha\beta(\bar{c}\bar{y}/\bar{k}^2) + \theta(\alpha\bar{c}^2/\bar{k}^2)] < 0$, where $\bar{y} = \bar{k}^\alpha\bar{l}^\beta$, in a steady state equilibrium with an elastic labor supply. Second, when domestic households supply their labor inelastically (i.e., $\theta = 0$), the determinant of J is $-\alpha\beta[\bar{c}\bar{y}/\bar{k}^2] < 0$, where $\bar{y} = \bar{k}^\alpha(1 + \varphi)^\beta$ in a long-run equilibrium with illegal immigration.¹⁷

Under the uniqueness and stability property, we examine how the fundamentals in the labor market affect steady state consumption, capital, employment, aggregate consumption, and final output. Of particular interests are μ and φ , the wage difference between domestic and illegal immigration workers and the number of illegal immigrants per domestic household, respectively. The following lemma summarizes how a change in the wage differences affects the steady state equilibrium in a dynamic *laissez-faire* economy.

Lemma 3. *An increase in the wage difference between domestic workers and illegal immigrants increases steady state consumption \bar{c} per domestic household but decreases steady state capital stocks \bar{k} per domestic household and domestic employment \bar{l} . In addition, an increase in the wage difference increases steady state aggregate domestic consumption \bar{C} , but decreases steady state aggregate final output \bar{Y} and steady state aggregate illegal immigrant's consumption \bar{C}^* in a dynamic *laissez-faire* economy with illegal immigration.*

Proof. *Ceteris paribus*, a small μ captures an increases in the wage differences. From (14)-(20), a simple computation yields that $d\bar{c}/d\mu < 0$, $d\bar{k}/d\mu > 0$, $d\bar{l}/d\mu > 0$, $d\bar{C}/d\mu < 0$, $d\bar{Y}/d\mu > 0$, and $d\bar{C}^*/d\mu > 0$. \square

The welfare effects of the wage difference in the previous lemma are intuitive. First, a smaller μ increases the producer's profit. Then, the larger profit yields higher dividends to each domestic household. Second, due to the additional dividends, each domestic household increases consumption and leisure so that aggregate domestic consumption also increases. Third, the increase in leisure reduces the domestic labor supply along with the fixed number of illegal immigrants. Then, the steady state capital stock per domestic household declines in the long run. Fourth, the decrease in the capital stock, along with the small domestic labor supply, reduces the aggregate final output. Accordingly, a smaller μ reduces the steady state aggregate final output in the steady state competitive equilibrium with illegal immigration.

¹⁷When $\theta = 0$, $\bar{l} = 1$. Thus, $\Omega = 1$.

Lemma 3 implies that the wage difference affects the steady state capital (see (15)), but this implication is contrary to a competitive equilibrium with exogenous domestic labor supply. For example, Palivos (2009) shows that the steady state capital is independent of the wage difference between domestic workers and illegal immigrants. Also, introducing an elastic labor supply allows the trade-off between the domestic household's welfare and the aggregate final output. This trade-off sacrifices the level of aggregate final output (see (20)), although a larger wage difference increases the domestic household's consumption and thus raises aggregate domestic consumption. Hence, the uneven wage profile in a competitive economy improves domestic households' welfare but harms the aggregate economic performance in the long run. It suggests that any sociopolitical changes – for example, a border control measure, immigration regulations, anti-immigration, and so on – to the wage differences create these individual and aggregate mixed effects, causing contentious academic and public debates on illegal immigration.

Now we examine the effect of a change in the proportion of illegal immigrants with respect to domestic workers in production. The following lemma summarizes our findings.

Lemma 4. *An increase in the number of illegal immigrants with respect to domestic workers increases steady state consumption \bar{c} and capital stocks \bar{k} per domestic household but decreases steady state employment \bar{l} in the domestic labor market. In addition, an increase in the number of illegal immigrants with respect to domestic workers increases steady state aggregate domestic consumption \bar{C} and illegal immigrant's consumption \bar{C}^* as well as steady state aggregate final output \bar{Y} in the long run.*

Proof. Ceteris paribus, recall that a large φ captures a large proportion of illegal immigrants in the domestic labor market. Then, from (14)-(20), we have that $d\bar{c}/d\varphi > 0$, $d\bar{k}/d\varphi > 0$, $d\bar{l}/d\varphi < 0$, $d\bar{C}/d\varphi > 0$, $d\bar{Y}/d\varphi > 0$, and $d\bar{C}^*/d\varphi > 0$. \square

The mechanism of the previous results in Lemma 4 is as follows. First, ceteris paribus, an increase in the proportion of illegal immigrants raises the producer's profit. Second, the additional income of domestic households arises due to large dividends. Third, the domestic household increases both normal goods: consumption and leisure. Hence, illegal immigration has a positive welfare effect on domestic households. Furthermore, the steady state capital stocks per domestic household increase in a large proportion of illegal immigrants. That is, although domestic households reduce their working hours, the large number of illegal immigrants offsets the reduction of the total labor employment in production.¹⁸ Hence, the aggregate final

¹⁸This argument is based on that $-1 < d\bar{l}/d\varphi < 0$ in (16).

output also increases in a dynamic laissez-faire economy.

In sum, Lemmas 3 and 4 verify that the welfare of the domestic households always increases in the presence of a large wage difference and a high proportion of illegal immigrants in the domestic labor market. However, the wage difference causes a different long-run effect of illegal immigration on the aggregate final output. The wage difference and the proportion of illegal immigrants are closely related to each other in the domestic labor market. For example, an increase or decrease in illegal immigrants would change the wage differential between domestic workers and illegal immigrants. Furthermore, the border control policy,¹⁹ the source country's wage, the detection rate in a receiving country, and many other factors also play an important role in influencing the supply of illegal immigrants and/or the wage differentials in a receiving country (see the survey in [Hanson 2006](#)). Nevertheless, in the present paper, the wage difference is orthogonal to the number of illegal immigrants available in the labor market. This decomposition allows us to study analytically the two separate effects of those elements in the competitive equilibrium in the presence of illegal immigration.²⁰

3 Illegal immigrants under fiscal policies

In this section we extend the dynamic laissez-faire economy with no fiscal policies to a decentralized competitive economy with fiscal policies in the presence of illegal immigration. We consider a passive role of government policies in a sense that fiscal policies are neither socially optimal nor endogenously determined by taking into account on the private agent's reactions. More specifically, we consider that capital and labor taxes are constant over the periods, and the government's tax revenues are transferred without distortion to the domestic households. The government also balances its budget in each period. Following from the immigration literature, we start with the assumption that an illegal immigrant pays no tax and receives no income transfer. In later discussions, we relax this assumption.

3.1 Competitive equilibrium with benchmark fiscal policies

In a decentralized competitive economy, we introduce the following benchmark fiscal policies in which the government levies capital income tax $\tau_k^h \in [0, 1)$ on the domestic households and payroll tax $\tau_l^f \in [0, 1)$ on the domestic labor input but not on illegal immigrants in produc-

¹⁹Refer to [Ethier \(1986a, 1986b\)](#), [Bond and Chen \(1987\)](#), and [Woodland and Yoshida \(2006\)](#).

²⁰Depending on the elasticity of the labor demand and supply, existing empirical findings can either over- or underestimate the impacts of illegal immigration in the domestic labor market.

tion.²¹ The government redistributes total tax revenue to domestic households through lump-sum income transfers $T(t)$ for each period. The domestic household's budget constraints are summarized as

$$\dot{k} + c = (1 - \tau_k^h)rk + wl + \pi + T/z. \quad (23)$$

The domestic household's problem is to maximize the intertemporal utility (1) subject to the household's budget constraints (22). Hence, along with (4), $w(t) = \frac{\theta c(t)}{1-l(t)}$, the first order condition for the household's problem is

$$\frac{\dot{c}}{c} = (1 - \tau_k^h)r - \rho. \quad (24)$$

Therefore, the necessary and sufficient conditions are (4), (22), and (23) including the corresponding transversality condition as in (5). As in Proposition 1, the existence of the unique solution to the domestic household's problem is guaranteed under the conditions on the lifetime utility function.

Now we define the producer's optimization problem. Given the payroll tax $\tau_l^f \in [0, 1)$ on the domestic labor input, the representative producer maximizes the following profit:

$$\Pi = Y - rK - (1 + \tau_l^f)wzl - w^*z^*. \quad (25)$$

Notice that the representative producer does not pay any input tax for the illegal immigrant's labor input. The first order conditions are the return to capital, $r = \alpha y/k$ as in (7) and the wage rate with τ_l^f :

$$w = \frac{\beta}{1 + \tau_l^f} \frac{y}{\varphi + l} = \frac{\beta}{1 + \tau_l^f} k^\alpha (\varphi + l)^{\beta-1}. \quad (26)$$

Under the benchmark fiscal policies, total tax revenues are $\tau_k^h rK + \tau_l^f wzl$ along with the income transfers $T(t)$ to domestic households. The balanced budget constraints are

$$\tau_k^h rK + \tau_l^f wzl = T. \quad (27)$$

We now characterize the decentralized competitive equilibrium under the benchmark fiscal policies in the presence of illegal immigration. By using (7), (24), (25), the representative

²¹Note that τ_B^A denotes that the government imposes "a type B tax on an agent A " where a superscript A , $A = h, f$ represents domestic household h and producer f , respectively, and subscript B , $B = k, l$ represents capital k and labor l , respectively.

producer's profit in the equilibrium is

$$\Pi = (1 - \mu)wz^* + \tau_l^f wz^*. \quad (28)$$

The producer's profit consists of the two parts as in (27). As in the laissez-faire economy with no fiscal policy, the first term of the profit (see (9)) is from the gains from a low wage rate of illegal immigrants. The second term captures the profit from tax loophole by hiring illegal immigrants on whom no payroll tax is imposed. Interestingly, this part of the profit is thought of as illegal immigrants' contributing to the amount of payroll tax to the producer. This tax incidence creates a distinct difference between the equilibrium in the dynamic laissez-faire economy with no fiscal policy and the equilibrium in the decentralized competitive economy with benchmark fiscal policies.

To examine the effect of fiscal policies, we characterize the decentralized competitive equilibrium with benchmark fiscal policies. First, we find that the wage income for the domestic household $wl = \beta y / (1 + \tau_l^f) - w\varphi$ in (25); the capital income $rk = \alpha y$ in (7); the dividends $\pi = (1 - \mu)\varphi w + \tau_l^f \varphi w$ in (27); and the income transfers per domestic household $T/z = \tau_k^h rk + \tau_l^f wl$ in (26). Then, under any feasible exogenous fiscal policy $\{\tau_k^h, \tau_l^f\}$ and lump-sum income transfers T , the system of the dynamic equations for the equilibrium $\{c, k, l\}$ satisfies that, for each period $t \in [0, \infty)$:

$$\frac{\dot{c}}{c} = \alpha(1 - \tau_k^h)k^{\alpha-1}(\varphi + l)^\beta - \rho, \quad (29)$$

$$\frac{\dot{k}}{k} = k^{\alpha-1}(\varphi + l)^\beta - \frac{c}{k} - \varphi \left[\frac{\mu\beta k^{\alpha-1}(\varphi + l)^{\beta-1}}{1 + \tau_l^f} \right], \quad (30)$$

$$\frac{\theta c}{1 - l} = \frac{\beta k^\alpha (\varphi + l)^{\beta-1}}{1 + \tau_l^f}. \quad (31)$$

In addition, summing (28) over z number of domestic households leads to the aggregate feasibility condition in a decentralized competitive economy with benchmark fiscal policies:

$$\dot{K} = Y - C - \varphi \left[\frac{\mu\beta Y}{(1 + \tau_l^f)(\varphi + l)} \right]. \quad (32)$$

Also, we find that the consumption per illegal immigrant is $C^* = \varphi [\mu\beta Y / (1 + \tau_l^f)(\varphi + l)]$.

The following proposition summarizes the property for the decentralized competitive equilibrium with benchmark fiscal policies.

Proposition 3. *Under the assumptions on technology and preferences with elastic domestic labor supply and given any feasible fiscal policy $\{\tau_k^h, \tau_l^f\}$ with lump-sum income transfers $T(t)$ to the domestic households, the competitive equilibrium exists with illegal immigration if and only if the feasible allocation $c(t), k(t), l(t), c^*(t), C(t)$, and $Y(t)$ with the initial capital stock k_0 satisfies conditions (25) and (27)-(30) with the transversality condition (5).*

This proposition generalizes the dynamic laissez-faire equilibrium in the previous section by introducing benchmark fiscal policies: capital income tax on domestic households and payroll tax on producers. The uniqueness and stability property prevails for the decentralized competitive equilibrium under benchmark fiscal policies. It is because the fiscal policies are exogenous.

3.2 Long-run equilibrium with benchmark fiscal policies

We next focus on the long-run equilibrium of the dynamic equilibrium $\{c, k, l, c^*, C, Y\}$ in a decentralized competitive economy with benchmark fiscal policies. Let $\tilde{c}, \tilde{k}, \tilde{l}, \tilde{c}^*, \tilde{C}$, and \tilde{Y} be a steady state allocation, where each variable becomes constant in the long run. That is, $\dot{c} = 0$, $\dot{k} = 0$, and $\dot{l} = 0$ in (25) and (27)~(30), we find that the steady state allocation $\{\tilde{c}, \tilde{k}, \tilde{l}, \tilde{Y}, \tilde{C}, \tilde{C}^*\}$ is

$$\tilde{c} = \left(\frac{\alpha(1 - \tau_k^h)}{\rho} \right)^{\frac{\alpha}{1-\alpha}} \left\{ \frac{\beta}{\beta + \theta(1 + \tau_l^f)} \left[1 + \varphi \left(1 - \frac{\mu\beta}{1 + \tau_l^f} \right) \right] \right\}, \quad (33)$$

$$\tilde{k} = \left(\frac{\alpha(1 - \tau_k^h)}{\rho} \right)^{\frac{1}{1-\alpha}} \left\{ \frac{\beta[1 + \varphi(1 + \theta\mu)]}{\beta + \theta(1 + \tau_l^f)} \right\}, \quad (34)$$

$$\tilde{l} = \frac{\beta - \theta\varphi[-\mu\beta + (1 + \tau_l^f)]}{\beta + \theta(1 + \tau_l^f)}, \quad (35)$$

$$\tilde{c}^* = \left(\frac{\alpha(1 - \tau_k^h)}{\rho} \right)^{\frac{\alpha}{1-\alpha}} \left[\frac{\mu\beta}{(1 + \tau_l^f)(\varphi + \tilde{l})} \right] \left\{ \varphi + \left[\frac{\beta - \theta\varphi[-\mu\beta + (1 + \tau_l^f)]}{\beta + \theta(1 + \tau_l^f)} \right] \right\}, \quad (36)$$

$$\tilde{C} = \left(\frac{\alpha(1 - \tau_k^h)}{\rho} \right)^{\frac{\alpha}{1-\alpha}} \left\{ \frac{\beta z}{\beta + \theta(1 + \tau_l^f)} \left[1 + \varphi \left(1 - \frac{\mu\beta}{1 + \tau_l^f} \right) \right] \right\}, \quad (37)$$

$$\tilde{Y} = \left(\frac{\alpha(1 - \tau_k^h)}{\rho} \right)^{\frac{\alpha}{1-\alpha}} \left\{ \varphi z + z \left[\frac{\beta - \varphi \theta [-\mu \beta + (1 + \tau_l^f)]}{\beta + \theta(1 + \tau_l^f)} \right] \right\}. \quad (38)$$

The properties of the steady state equilibrium are as follows. First, (31)~(36) show that the steady state allocation $\{\tilde{c}, \tilde{k}, \tilde{l}, \tilde{c}^*, \tilde{C}, \tilde{Y}, \}$ is unique and stable.²² Second, the both capital and payroll taxes are distortionary in the agent's optimal decisions and thus in the aggregate equilibrium allocation. Third, the properties of welfare in the presence of illegal immigration in Lemmas 1 and 2 for the dynamic laissez-faire economy prevail in a decentralized competitive economy with benchmark fiscal policies. For example, the presence of illegal immigration increases steady state consumption \tilde{c} and capital stocks \tilde{k} but decreases steady state employment \tilde{l} of domestic households. In addition, the elastic domestic labor supply decreases steady state consumption \tilde{c} and capital stocks \tilde{k} per domestic household. Finally, illegal immigration increases the steady state aggregate consumption \tilde{C} and the aggregate final output \tilde{Y} under exogenous fiscal policies.

Therefore, we form the following corollary on welfare under benchmark fiscal policies.

Corollary 3. *Under the conditions of Proposition 3, illegal immigration has a positive impact on the steady state welfare in a decentralized competitive economy under exogenous fiscal policy $\{\tau_k^h, \tau_l^f\}$ with lump-sum income transfers T to the domestic households. In addition, illegal immigration increases the steady state aggregate domestic consumption and aggregate final output in the long run.*

Along with Corollaries 1 and 2, this corollary shows that the positive effect of illegal immigrants is robust in the competitive equilibrium with an elastic labor supply and an exogenous fiscal policy. Furthermore, the properties in Lemmas 3 and 4 in the dynamic laissez-faire economy also prevail in a decentralized competitive economy under benchmark fiscal policies. More specifically, widening the wage difference between domestic workers and illegal immigrants increases steady state consumption \tilde{c} but lowers capital stocks \tilde{k} , and employment \tilde{l} . On the other hand, steady state aggregate final output \tilde{Y} falls whereas steady state aggregate domestic consumption \tilde{C} rises. Hence, the wage difference yields the opposite consequence on individual welfare and the aggregate economy with fiscal policies. Furthermore, we also find that an increase in the number of illegal immigrants raises steady state consumption \tilde{c} and capital stock \tilde{k} but decreases employment \tilde{l} . In addition, an increase in the number of illegal immigrants raises

²²By letting $\tilde{\beta} = \beta / (1 + \tau_l^f)$ and $\tilde{\alpha} = (1 - \tau_k^h)\alpha$, we can easily demonstrate that the transitional path $\{c, k, l\}$ in (28)-(30) is unique and saddle stable in the unique steady state $\{\tilde{c}, \tilde{k}, \tilde{l}\}$ in (33)-(35). This property validates the dynamic comparative analysis in the next corollary and proposition.

steady state aggregate domestic consumption \tilde{C} as well as steady state aggregate final output \tilde{Y} .

We are now able to examine the effect of taxation on the steady state competitive equilibrium under benchmark fiscal policies. The following proposition summarizes the results of comparative dynamic analysis.

Proposition 4. *Under the conditions of Proposition 3, an increase in capital income tax rate τ_k^h lowers steady state consumption \tilde{c} and capital stocks \tilde{k} per domestic household and thus steady state aggregate domestic consumption \tilde{C} along with steady state aggregate illegal immigrant's consumption \tilde{C}^* . On the other hand, an increase in capital income tax τ_k^h has no impact on steady state labor supply \tilde{l} of the domestic household but decreases steady state aggregate final output \tilde{Y} . In addition, an increase in payroll tax rate τ_l^f decreases steady state consumption \tilde{c} and capital stocks \tilde{k} per domestic household and labor supply \tilde{l} of domestic households and thus decreases steady state aggregate domestic consumption \tilde{C} , aggregate final output \tilde{Y} , and illegal immigrants' consumption \tilde{C}^* .*

Proof. From (33)–(37), we have that $d\tilde{c}/d\tau_k^h < 0$, $d\tilde{k}/d\tau_k^h < 0$, $d\tilde{l}/d\tau_k^h = 0$, $d\tilde{Y}/d\tau_k^h < 0$, and $d\tilde{C}^*/d\tau_k^h < 0$ for capital income taxes τ_k^h on domestic households. We also have that $d\tilde{c}/d\tau_l^f < 0$, $d\tilde{k}/d\tau_l^f < 0$, $d\tilde{l}/d\tau_l^f < 0$, $d\tilde{Y}/d\tau_l^f < 0$, and $d\tilde{C}^*/d\tau_l^f < 0$ for payroll taxes τ_l^f on the producer in a decentralized competitive economy. \square

As expected from prior public finance literature, we verify that the capital income tax and payroll tax have an unambiguously negative impact on steady state consumption and capital stocks. However, capital income tax τ_k^h has no impact on the domestic labor supply, whereas payroll tax τ_l^f always reduces the labor supply of the domestic household. Hence, the capital income tax on domestic households unambiguously reduces the welfare of domestic households, whereas the payroll tax on production has an ambiguous effect on the welfare of domestic households. This ambiguity is from the opposite effects of the payroll tax on consumption and leisure. Again, as expected from any distortionary taxes, Proposition 4 verifies that both aggregate final output and aggregate domestic consumption decrease unambiguously in both capital income tax and payroll tax in the long-run competitive equilibrium.

3.3 Nonequivalence between labor income taxes and payroll taxes

In this subsection, we consider the case of the labor income tax τ_l^h on domestic households versus the payroll tax τ_l^f on the producer. We address the welfare effect on domestic households under the fiscal tax policy $\{\tau_k^h; \tau_l^h\}$ as oppose to the benchmark tax policy $\{\tau_k^h; \tau_l^f\}$ in the previous subsections. In a standard dynamic general equilibrium economy, a statutory tax on

either the demand or the supply yields the same tax incidence and results in the the same social welfare effects (Atkinson and Stiglitz 2015). We, however, argue that equivalence of such a tax incidence no longer holds in a decentralized competitive economy with illegal immigration. Hence, domestic households' welfare depends on who is statutorily responsible for taxation.

Under fiscal policies with capital income tax and labor income taxes $\{\tau_k^h, \tau_l^h\}$ with lump-sum income transfers T , the domestic household maximizes its intertemporal utility (1) subject to modified budget constraints with $\{\tau_k^h, \tau_l^h\}$: $\dot{k} + c = (1 - \tau_k^h)rk + (1 - \tau_l^h)wl + \pi + T/z$. Then, the necessary and sufficient conditions are $\dot{c} = (1 - \tau_k^h)r - \rho$ as in (23) and $\theta c/(1 - l) = (1 - \tau_l^h)w$. The producer's maximization problem yields the same first-order condition as in (6)-(8) as in the dynamic laissez-faire economy. Finally, the government satisfies the balanced budget constraints: $\tau_k^h rK + \tau_l^h wzl = T$.

After some algebra, we can show the steady state consumption per domestic household, capital per domestic household, and labor supply of domestic worker as, respectively,

$$\tilde{c} = \left(\frac{\alpha(1 - \tau_k^h)}{\rho} \right)^{\frac{\alpha}{1-\alpha}} \left\{ \frac{\beta(1 - \tau_l^h)}{\theta + \beta(1 - \tau_l^h)} \left[1 + \varphi(1 - \beta\mu) \right] \right\}, \quad (39)$$

$$\tilde{k} = \left(\frac{\alpha(1 - \tau_k^h)}{\rho} \right)^{\frac{1}{1-\alpha}} \left\{ \frac{\beta(1 - \tau_l^h)}{\theta + \beta(1 - \tau_l^h)} \left[1 + \varphi \left(1 + \frac{\theta\mu}{1 - \tau_l^h} \right) \right] \right\}, \quad (40)$$

$$\tilde{l} = \frac{\beta(1 - \tau_l^h) - \varphi\theta(1 - \beta\mu)}{\theta + \beta(1 - \tau_l^h)}. \quad (41)$$

Under fiscal policies $\{\tau_k^h; \tau_l^h\}$ with T , the properties of the competitive equilibrium in (37)~(39) are qualitatively different in tax incidence from those for benchmark fiscal policies $\{\tau_k^h; \tau_l^f\}$ with T in (31)~(33). We state the nonequivalence in tax incidence between $\{\tau_k^h; \tau_l^h\}$ and $\{\tau_k^h; \tau_l^f\}$ in the following proposition.

Proposition 5. (Nonequivalence Theorem) *In the presence of illegal immigrants, the statutory taxation of $\{\tau_k^h; \tau_l^h\}$ is not equivalent to that of $\{\tau_k^h; \tau_l^f\}$ in the long-run competitive equilibrium with lump-sum income transfers T to domestic households.*

Proof. It is immediate because there is no mapping from τ_l^h to τ_l^f such that the long-run equilibrium conditions of (37)~(39) for $\{\tau_k^h; \tau_l^h\}$ satisfies those of (31)~(33) for $\{\tau_k^h; \tau_l^f\}$ in benchmark fiscal policies.²³ \square

The nonequivalence theorem in tax incidence is mainly driven by the different distor-

²³Notice that a natural mapping function can be $1/(1 + \tau_l^f) = (1 - \tau_l^h)$, but this function fails for the equivalence.

tionary effect from the two different taxes in addition to the income transfer policy and the domestic household's ownership of the producer's profits in the presence of illegal immigration. Note that domestic households receive dividends from the representative producer. As in (27), the producer's profits include not only gains from underpayment to illegal immigrants but also from not paying taxes for employment of illegal immigrants. Hence, under benchmark fiscal policies $\{\tau_k^h; \tau_l^f\}$, the unpaid part of the tax revenue from illegal immigrants indirectly contributes to domestic households, and therefore domestic households collect all of the implicit labor tax revenues through their ownership of the producer's profits. This channel, however, no longer exists when the government collects and transfers the labor income tax to domestic households under fiscal policies $\{\tau_k^h; \tau_l^h\}$. In this case, no labor income tax is imposed on illegal immigrants' income, and thus no tax distortion arises in the production in a decentralized competitive economy. This analysis provides the next corollary.

Corollary 4. *The welfare of domestic households under statutory taxes $\{\tau_k^h; \tau_l^h\}$ is lower than it is under statutory taxes $\{\tau_k^h; \tau_l^f\}$ in the benchmark fiscal policies in the presence of illegal immigration.*

Nevertheless, fiscal policies $\{\tau_k^h; \tau_l^h\}$ with T yield the same dynamic comparative properties as the benchmark fiscal policies (see Lemmas 3 and 4 and Proposition 4). More specifically, the wage difference increases steady state consumption but decreases steady state employment and capital stocks; an increase in the number of illegal immigrants raises steady state consumption and capital stocks but decreases steady state employment in the presence of illegal immigrants in the domestic labor market. The impact of these taxes on the decentralized competitive equilibrium is qualitatively identical to that of the corresponding set of taxes in the benchmark fiscal policies.

3.4 Equivalence theorem in tax incidence

In the previous section, we demonstrate that the labor income tax on domestic households is not equivalent to the payroll tax on the producer. However, in this subsection, we demonstrate a few tax policies that induce the same welfare effect on domestic households in the presence of illegal immigration. We consider two sets of fiscal policies that ensure the welfare equivalence to the benchmark fiscal policies $\{\tau_k^h; \tau_l^f\}$ with lump-sum income transfers T . In the first case that $\{\tau_k^h; \tau_l^h; \tau_{l^*}^*\}$ with income transfers T , illegal immigrants pay labor income tax $\tau_{l^*}^*$ where domestic households pay capital income tax τ_k^h and labor income tax τ_l^h . In the second case that $\{\tau_k^h; \tau_l^f; \tau_{l^*}^f\}$ with lump-sum income transfers T , domestic households pay capital income

tax τ_k^h , the producer pays the payroll tax on the labor input of domestic workers τ_l^f and illegal immigrants $\tau_{l^*}^f$. The following equivalence theorem on the set of above taxes shows that the agents' optimum decisions and the equilibrium allocations are equivalent in the three sets of the fiscal policies.

Proposition 6. (Equivalence Theorem) *In a decentralized competitive economy with illegal immigrants, the two sets of tax policies $\{\tau_k^h; \tau_l^h; \tau_{l^*}^*\}$ and $\{\tau_k^h; \tau_l^f; \tau_{l^*}^f\}$ with lump-sum income transfers T is equivalent to the benchmark tax policies $\{\tau_k^h; \tau_l^f\}$ with lump-sum income transfers T . Hence, all three sets of fiscal policies have the same welfare effect on domestic households in the dynamic competitive economy.*

Proof. First, we show that illegal immigrants' effects on the domestic household's welfare under benchmark tax policy $\{\tau_k^h; \tau_l^f\}$ are identical to those under tax policy $\{\tau_k^h; \tau_l^h; \tau_{l^*}^*\}$. To do so, we identify that, under $\{\tau_k^h; \tau_l^h; \tau_{l^*}^*\}$ with T , the domestic household's budget constraints is $\dot{k} + c = (1 - \tau_k^h)rk + (1 - \tau_l^h)wl + \pi + T/z$. Then, the necessary and sufficient conditions for the domestic household's problem are $\theta c/(1 - l) = (1 - \tau_l^h)w$ together with (23) under $\{\tau_k^h; \tau_l^f\}$. The first-order conditions for the producer's problem are identical to those in (6)-(8) under $\{\tau_k^h; \tau_l^f\}$. Thus, we have that $\Pi = (1 - \mu)wz^*$. The balanced budget constraints are $\tau_k^h rK + \tau_l^h wzl + \tau_{l^*}^* \mu wz^* = T$. Therefore, putting all these equilibrium conditions together and setting $1/(1 + \tau_l^f)$ being equal to $(1 - \tau_l^h)$, the system of dynamic equations of $\{c, k, l\}$ under $\{\tau_k^h; \tau_l^h; \tau_{l^*}^*\}$ is equivalent to those in (28)-(30) to a decentralized competitive economy with the benchmark fiscal policies $\{\tau_k^h; \tau_l^f\}$ with T .

Next, we show that illegal immigrants' effects on domestic households under $\{\tau_k^h; \tau_l^f; \tau_{l^*}^f\}$ are identical to those under benchmark tax policies $\{\tau_k^h; \tau_l^f\}$. Under $\{\tau_k^h; \tau_l^f; \tau_{l^*}^f\}$, the necessary and sufficient conditions for the domestic household's problem remain the same as (4), (22), and (23) under $\{\tau_k^h; \tau_l^f\}$. The first-order conditions for the producer's problem also remain the same as (7) and (25) under $\{\tau_k^h; \tau_l^f\}$. The only difference arises from the producer's profit, $\Pi = (1 - \mu)wz^* + (1 - \mu)\tau_{l^*}^f wz^*$, which is modified from (27) under $\{\tau_k^h; \tau_l^f\}$. The balance budget constraints are $\tau_k^h rK + \tau_l^f wzl + \tau_{l^*}^f \mu wz^* = T$. Again, putting all equilibrium conditions together under $\{\tau_k^h; \tau_l^f; \tau_{l^*}^f\}$, the system of the dynamic equations of $\{c, k, l\}$ under $\{\tau_k^h; \tau_l^f; \tau_{l^*}^f\}$ is equivalent to the one in (28)-(30) for a decentralized competitive economy with benchmark fiscal policies $\{\tau_k^h; \tau_l^f\}$ with T . \square

A simple observation from the equivalence theorem is that the three sets of statutory tax policies qualitatively share the same aggregate resource constraints. For example, along with the government's lump-sum income transfers to domestic households, the domestic household's returns to capital and the dividends of the producer's profits are transferred to domestic house-

holds as in $\{\tau_k^h; \tau_l^f; \tau_{l^*}^f\}$. That is, $T + \Pi = \tau_k^h rK + \tau_l^f w_z l + \tau_{l^*}^f w_z z^* + (1 - \mu)w_z z^*$ under any feasible capital income tax τ_k^h and payroll taxes τ_l^f and $\tau_{l^*}^f$, respectively, from the domestic workers and illegal immigrants. Hence, $T + \Pi$ under $\{\tau_k^h; \tau_l^f; \tau_{l^*}^f\}$ is identical to those under benchmark tax policies $\{\tau_k^h; \tau_l^f\}$. A similar argument can be applied to $\{\tau_k^h; \tau_l^h; \tau_{l^*}^*\}$. This finding leads to the previous proposition.

The equivalence theorem implies that the comparative dynamic analysis on the decentralized competitive equilibrium under benchmark fiscal policies must be identical to that under the previously described sets of the fiscal policies. Hence, the previous welfare and comparative dynamic analyses are robust in the decentralized competitive equilibrium with illegal immigration. We now report a few important results in the following corollary.

Corollary 5. *In a decentralized competitive economy with illegal immigrants, the three sets of tax policies, $\{\tau_k^h; \tau_l^f\}$, $\{\tau_k^h; \tau_l^h; \tau_{l^*}^*\}$, and $\{\tau_k^h; \tau_l^f; \tau_{l^*}^f\}$ with lump-sum income transfer T yield the same effects on steady state consumption \bar{c} and capital stocks \bar{k} per domestic household, and employment \bar{l} in the domestic labor market. Consequently, all three sets of tax policies decrease the welfare of domestic households in a decentralized competitive economy. Furthermore, under the three sets of fiscal policies, the wage differences between domestic households and illegal immigrants and the number of illegal immigrants in the domestic labor market have the same corresponding effects on the decentralized competitive equilibrium in the long run.*

Proof. Based on the equivalence property of the tax incidence in Proposition 6, the first part of corollary is from Proposition 4; the second part is from Lemma 3; and the last part is from Lemma 4.

4 Fiscal burden and labor income taxes

In this section, we extend our attention to a variation of fiscal policies under which both domestic households and illegal immigrants receive income transfers from the government. The income transfers induce a fiscal burden or drain on domestic households depending on two alternative tax policies: $\{\tau_l^h\}$ and $\{\tau_l^h; \tau_{l^*}^*\}$.²⁴ In the first case, we consider that each domestic household pays the labor income tax τ_l^h but an illegal immigrant does not pay any taxes; in the second case, both domestic households and illegal immigrants pay the labor income tax, τ_l^h and

²⁴The annual Social Security contributions from invalid Social Security numbers rose from \$7 billion to \$49 billion during 1986-2000 (Social Security Administration, 2003). Even though no immediate release of those funds as made to the general public, the Social Security Administration eventually has been rolled into the general funds of the federal government.

τ_l^* , respectively.²⁵

4.1 With no labor income tax on illegal immigrants

In this subsection, departing from previous fiscal policies where all of income transfers T are received by domestic households, we consider that illegal immigrants also receive income transfers T^* . We begin with labor income tax $\{\tau_l^h\}$ on domestic households but not on illegal immigrants in a decentralized competitive economy. Domestic households experience a fiscal burden due to the income transfers T^* to illegal immigrants. First, the domestic household's budget constraints become $\dot{k} + c = rk + (1 - \tau_l^h)wl + \pi + T/z$. Then, the first order conditions for the domestic household's problem are $\frac{\dot{c}}{c} = r - \rho$ and $\theta c/(1 - l) = (1 - \tau_l^h)w$ along with the budget constraints and corresponding transversality condition. Second, the first-order conditions for the producer's problem are identical to those in (6)-(8) in the dynamic laissez-faire economy. Finally, the government uses the total tax revenues for the lump-sum income transfers T and T^* , and thus the balanced budget constraints imply that $\tau_l^h wzl = T + T^*$.

Suppose $\lambda \in (0, 1)$ denotes the degree of the fiscal burden on domestic households. The balanced budget constraints imply that

$$T = (1 - \lambda)\tau_l^h wzl, \quad T^* = \lambda\tau_l^h wzl. \quad (42)$$

Therefore, with a feasible labor income tax τ_l^h and a feasible fiscal burden λ on domestic households, the system of dynamic equations for $\{c, k, l\}$ in each period $t \in [0, \infty)$ is summarized as²⁶

$$\frac{\dot{c}}{c} = \alpha k^{\alpha-1}(\varphi + l)^\beta - \rho, \quad (43)$$

$$\frac{\dot{k}}{k} = k^{\alpha-1}(\varphi + l)^\beta - \frac{c}{k} - \varphi[\mu\beta k^{\alpha-1}(\varphi + l)^{\beta-1}] - \lambda \left[\frac{\beta\tau_l^h ly}{\varphi + l} \right], \quad (44)$$

$$\frac{\theta c}{1 - l} = \beta(1 - \tau_l^h)k^\alpha(\varphi + l)^{\beta-1}. \quad (45)$$

By summing (44) over z number of domestic households, we have the aggregate feasible conditions:

²⁵Focusing on the effect of income transfers, we abstract away from the capital income tax (i.e., $\tau_k^h = 0$) in this section. We also ignore the consumption tax on illegal immigrants. Note that the consumption tax is not distortionary and thus has only an income effect on equilibrium; thus the full analysis is straightforward.

²⁶Domestic households have no fiscal burden when λ approaches zero. Given $\tau_k^h = 0$, (42) is identical to (26), and the agents' optimal conditions (28)-(30) are identical to (43)-(45).

$$\dot{K} = Y - C - \left[\frac{\beta(\mu\varphi + \lambda\tau_l^h)Y}{\varphi + l} \right]. \quad (46)$$

Then, the aggregate consumption for illegal immigrants is $C^* = [\beta(\mu\varphi + \lambda\tau_l^h)Y/(\varphi + l)]$.

Now, we characterize the decentralized competitive equilibrium with fiscal policies including τ_l^h and λ with T and T^* .

Proposition 7. *Under the assumptions on technology and preferences with an elastic domestic labor supply in a decentralized competitive economy with any feasible labor income tax τ_l^h and fiscal burden λ on domestic households, the competitive equilibrium with illegal immigration exists from the initial capital stock k_o if and only if the feasible allocation $c(t)$, $k(t)$, $l(t)$, $c^*(t)$, $C(t)$, and $Y(t)$ satisfies the dynamic equations in (41)~(43) with the market-clearing conditions in (44) and the transversality condition (5).*

From (41)~(44), we derive steady state allocation $\{\hat{c}, \hat{k}, \hat{l}, \hat{c}^*, \hat{C}, \hat{Y}\}$ of the decentralized competitive equilibrium with labor income tax τ_l^h and fiscal burden λ on domestic households as

$$\hat{c} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left\{ \beta(1 - \tau_l^h) \left[\frac{1 + \varphi(1 - \beta\mu) - \lambda\beta\tau_l^h}{\beta(1 - \tau_l^h) + \theta(1 - \lambda\beta\tau_l^h)} \right] \right\}, \quad (47)$$

$$\hat{k} = \left(\frac{\alpha}{\rho}\right)^{\frac{1}{1-\alpha}} \left\{ \frac{\beta[(1 - \varphi)(1 - \tau_l^h) + \theta(\mu - \lambda\tau_l^h)]}{\beta(1 - \tau_l^h) + \theta(1 - \lambda\beta\tau_l^h)} \right\}, \quad (48)$$

$$\hat{l} = \frac{\beta(1 - \tau_l^h) - \varphi\theta(1 - \beta\mu)}{\beta(1 - \tau_l^h) + \theta(1 - \lambda\beta\tau_l^h)}, \quad (49)$$

$$\hat{c}^* = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left[\frac{\beta(\varphi\mu + \lambda\tau_l^h)}{\varphi + \hat{l}} \right] \left\{ \varphi - \left[\frac{\varphi\theta(1 - \beta\mu) - \beta(1 - \tau_l^h)}{\beta(1 - \tau_l^h) + \theta(1 - \lambda\beta\tau_l^h)} \right] \right\}, \quad (50)$$

$$\hat{C} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left\{ \beta^z(1 - \tau_l^h) \left[\frac{1 + \varphi(1 - \beta\mu) - \lambda\beta\tau_l^h}{\beta(1 - \tau_l^h) + \theta(1 - \lambda\beta\tau_l^h)} \right] \right\}, \quad (51)$$

$$\hat{Y} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left\{ \varphi^z - z \left[\frac{\varphi\theta(1 - \beta\mu) - \beta(1 - \tau_l^h)}{\beta(1 - \tau_l^h) + \theta(1 - \lambda\beta\tau_l^h)} \right] \right\}. \quad (52)$$

A few simple observations are as follows. First, the decentralized steady state competitive equilibrium $\{\hat{c}, \hat{k}, \hat{l}, \hat{c}^*, \hat{C}, \hat{Y}\}$ is unique in (45)~(50). Second, both labor income tax τ_l^h and fiscal burden λ are distortionary not only in the short run but also in the long run. Third, an

increase in labor income tax rate τ_l^h lowers the steady state consumption and capital per domestic household and the labor supply in the labor market (see Proposition 4). Finally, we recall that the decentralized competitive equilibrium includes the special case that the labor supply in domestic households is inelastic (i.e., $\theta = 0$) in a decentralized competitive economy with labor income tax and income transfers. Hence, the main properties in Lemmas 1-4 prevail for the decentralized competitive equilibrium. For example, illegal immigration raises steady state consumption and capital stocks per domestic household but decreases the labor supply of domestic households as in Lemma 1. The more elastic the labor supply is, the less the steady state consumption is as in Lemma 2. An increase in the wage difference between domestic households and illegal immigrants increases steady state consumption but lowers capital stocks and domestic employment as in Lemma 3. An increase in the number of illegal immigrants raises steady state consumption and capital stocks per domestic household but decreases domestic employment as in Lemma 4.

In addition, the next proposition and corollary summarize the additional properties of the decentralized competitive equilibrium with the fiscal burden on domestic households.

Proposition 8. *In a decentralized competitive economy in the presence of illegal immigration, an increase in the fiscal burden on domestic households reduces steady state consumption \hat{c} per domestic household but increases steady state capital stocks \hat{k} per domestic household and domestic household's work hours \hat{l} . Furthermore, an increase in the fiscal burden decreases steady state aggregate domestic consumption \hat{C} but increases steady state aggregate final output \hat{Y} . <<<<and illegal immigrant's consumption \hat{c}^* .>>>*

Proof. By the comparative dynamic analysis on (45)~(50), it is immediate from $\partial\hat{c}/\partial\lambda < 0$, $\partial\hat{k}/\partial\lambda > 0$, $\partial\hat{l}/\partial\lambda > 0$, $\partial\hat{C}/\partial\lambda < 0$, $\partial\hat{Y}/\partial\lambda > 0$. <<<<and $\partial\hat{c}^*/\partial\lambda > 0$ >>>. \square

Corollary 6. *Under the conditions of Proposition 7, the lump-sum income transfers to illegal immigrants have a negative impact on steady state welfare on the domestic households but a positive impact on aggregate final production in a decentralized competitive economy.*

Proof. Immediately from Proposition 8. \square

As expected, the long-run welfare for domestic households decreases when they bear the fiscal burden in the presence of illegal immigrants. However, the fiscal burden encourages the capital accumulation and labor supply of domestic households, thereby increasing the aggregate final output in a decentralized competitive economy. Hence, the fiscal burden leads to conflicting effects between the domestic household's welfare and the aggregate economic performance in a decentralized competitive economy. This finding can be a source of academic and public

debates in the presence of illegal immigration (Hanson, 2007). <<statement on income and substitution effects>>

4.2 With labor income tax on illegal immigrants

In this subsection we extend to the case in which both domestic households and illegal immigrants pay labor income taxes and receive the income transfers. Under those taxes $\{\tau_l^h; \tau_{l^*}^*\}$ and lump-sum income transfers T and T^* , the domestic household's budget constraints are $\dot{k} + c = rk + (1 - \tau_l^h)wl + \pi + T/z$. The first-order conditions for the domestic household's problem are $\frac{\dot{c}}{c} = (1 - \tau_k)r - \rho$, $\theta c/(1 - l) = (1 - \tau_l^h)w$ with the domestic household's budget constraints, and the corresponding transversality condition. For the producer's problem, the first-order conditions are same as those in (6)~(8) and the net profit for the producer is $\Pi = (1 - \mu)wz^*$ as in the dynamic laissez-faire economy. With the labor income taxes and transfers, the balanced budget constraints are $\tau_l^h wzl + \tau_{l^*}^* wz^* = T + T^*$.

Suppose $\xi \in (0, 1)$ denotes the degree of the fiscal burden on domestic households when illegal immigrants contribute a part of government tax revenues. Then, The lump-sum income transfers to domestic households and illegal immigrants are $T = (1 - \xi)[\tau_l^h wzl + \tau_{l^*}^* wz^*]$ and $T^* = \xi[\tau_l^h wzl + \tau_{l^*}^* wz^*]$, respectively, under the balanced budget constraints. Without loss of generality, we set $\tau_l^h = \tau_{l^*}^*$.²⁷ Then, with any feasible labor income tax $\tau_l^h (= \tau_{l^*}^*)$ on labor market and fiscal burden ξ on domestic households, the system of the dynamic equations for $\{c, k, l\}$ for each period $t \in [0, \infty)$ is summarized as

$$\frac{\dot{c}}{c} = \alpha k^{\alpha-1}(\varphi + l)^\beta - \rho, \quad (53)$$

$$\frac{\dot{k}}{k} = k^{\alpha-1}(\varphi + l)^\beta - \frac{c}{k} - \varphi \left[\beta(\mu - \tau_l^h)k^{\alpha-1}(\varphi + l)^{\beta-1} \right] - \xi \left[\frac{\beta \tau_l^h y}{\varphi + l} \right], \quad (54)$$

$$\frac{\theta c}{1 - l} = \beta(1 - \tau_l^h)k^\alpha(\varphi + l)^{\beta-1}. \quad (55)$$

From (54), the aggregate feasibility conditions are

$$\dot{K} = Y - C - \left[\frac{\beta[\xi \tau_l^h + \varphi(\mu - \tau_l^h)]Y}{\varphi + l} \right]. \quad (56)$$

²⁷Because the productivities of domestic households and illegal immigrants are identical, it is reasonable to assume that the two labor tax rates are also identical. Furthermore, for our purpose, we do not gain much by maintaining the two different tax rates for fiscal policies including income transfers.

Moreover, the aggregate consumption for illegal immigrants is $C^* = [\beta[\xi\tau_l^h + \varphi(\mu - \tau_l^h)]Y/(\varphi + l)]$.

Following from the Proposition 7, the decentralized competitive equilibrium exists with the fiscal burden on domestic households when the both domestic households and illegal immigrants pay labor income and receive lump sum income transfers. Moreover the dynamic equations (51)~(53) with the balanced budget constraints and the market clearing conditions in (54) are necessary and sufficient for the the decentralized competitive equilibrium.

Now we focus on the steady state allocation $\{\hat{c}, \hat{k}, \hat{l}, \hat{c}^*, \hat{C}, \hat{Y}\}$ from (51)~(54). A simple algebra yields that

$$\hat{c} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left\{ \beta(1 - \tau_l^h) \left[\frac{1 + \varphi[1 - \beta\mu + \beta(1 - \xi)\tau_l^h] - \xi\beta\tau_l^h}{\beta(1 - \tau_l^h) + \theta(1 - \xi\beta\tau_l^h)} \right] \right\}, \quad (57)$$

$$\hat{k} = \left(\frac{\alpha}{\rho}\right)^{\frac{1}{1-\alpha}} \left\{ \beta(1 - \tau_l^h) \left[\frac{1 + \varphi[1 + \theta(\mu - \tau_l^h)]}{\beta(1 - \tau_l^h) + \theta(1 - \xi\beta\tau_l^h)} \right] \right\}, \quad (58)$$

$$\hat{l} = \frac{\beta(1 - \tau_l^h) - \varphi\theta[1 - \xi\beta\tau_l^h - \beta(\mu - \tau_l^h)]}{\beta(1 - \tau_l^h) + \theta(1 - \xi\beta\tau_l^h)}, \quad (59)$$

$$\hat{c}^* = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left[\frac{\beta\mu - \beta(1 - \xi)\tau_l^h}{\varphi + \hat{l}} \right] \left\{ \varphi + \left[\frac{\beta(1 - \tau_l^h) - \varphi\theta[1 - \xi\beta\tau_l^h - \beta(\mu - \tau_l^h)]}{\beta(1 - \tau_l^h) + \theta(1 - \xi\beta\tau_l^h)} \right] \right\}, \quad (60)$$

$$\hat{C} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left\{ \beta z(1 - \tau_l^h) \left[\frac{1 + \varphi[1 - \beta\mu + \beta(1 - \xi)\tau_l^h] - \xi\beta\tau_l^h}{\beta(1 - \tau_l^h) + \theta(1 - \xi\beta\tau_l^h)} \right] \right\}, \quad (61)$$

$$\hat{Y} = \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \left\{ \varphi z + z \left[\frac{\beta(1 - \tau_l^h) - \varphi\theta[1 - \xi\beta\tau_l^h - \beta(\mu - \tau_l^h)]}{\beta(1 - \tau_l^h) + \theta(1 - \xi\beta\tau_l^h)} \right] \right\}. \quad (62)$$

From (55)~(60), the steady state allocation $\{\hat{c}, \hat{k}, \hat{l}, \hat{c}^*, \hat{C}, \hat{Y}\}$ shows that fiscal burden ξ on domestic households distorts the steady state equilibrium regardless of illegal immigrants' tax contribution. Hence, in a dynamic general equilibrium economy, the fiscal burden, along with income transfers to domestic households and illegal immigrants, generates a distortionary effect on the short- and long-run equilibrium in a decentralized competitive economy with illegal immigration.

The next proposition summarizes the comparative dynamic analysis on the domestic household's fiscal burden.

Proposition 10. *Under the fiscal policies that both domestic households and illegal immigrants pay labor income taxes and receive the income transfers, an increase in the fiscal burden on domestic households decreases steady state consumption \hat{c} per domestic household, but in-*

creases steady state capital stocks \hat{k} and domestic employment \hat{l} . In addition, the increase in the fiscal burden on domestic households decreases steady state aggregate domestic consumption \hat{C} but increases steady state aggregate final output \hat{Y} . <<<and illegal immigrants' consumption \hat{C}^* .>>>

Proof. It is immediate from (55)-(60) that $\partial \hat{c} / \partial \xi < 0$, $\partial \hat{k} / \partial \xi > 0$, $\partial \hat{l} / \partial \xi > 0$, $\partial \hat{C} / \partial \xi < 0$, and $\partial \hat{Y} / \partial \xi > 0$. <<and $\partial \hat{C}^* / \partial \xi > 0$.>> \square

The fiscal burden and income transfers to illegal immigrants have a negative impact on the steady state welfare of domestic households in a competitive economy. This negative welfare effect is intuitive: The net income transfers to illegal immigrants generate the negative income effect on capital accumulation (see (56), thereby changing consumption (see (55)) and labor supply (see (57)) of domestic households. This finding is contrary to the absence of an income effect found in the standard neoclassic growth economy a la Solow (1956) with no illegal immigration, where the lump-sum income transfers should offset the exact amount of the tax revenue in the balanced budget constraints.

The next corollary reports the conflicting effects of the fiscal burden on domestic households.

Corollary 7. *In a decentralized competitive economy with the fiscal burden on domestic households, the positive net income transfers to both illegal immigrants and domestic households have a negative impact on the steady state welfare on domestic households but a positive impact on the aggregate final output in a dynamic competitive economy with illegal immigration.*

Proof. This is immediately from Proposition 10. \square

This corollary shows that the fiscal burden on domestic households for income transfers to illegal immigrant hurts the welfare of domestic households regardless whether illegal immigrants take some share of government tax revenues. However, the fiscal burden encourages private investment and work hours of domestic households so that the final output increases in the aggregate long-run equilibrium. Similarly to Corollary 5, we find the conflicting effects between the domestic household's welfare and aggregate economic performance in the presence of fiscal burden on domestic households.

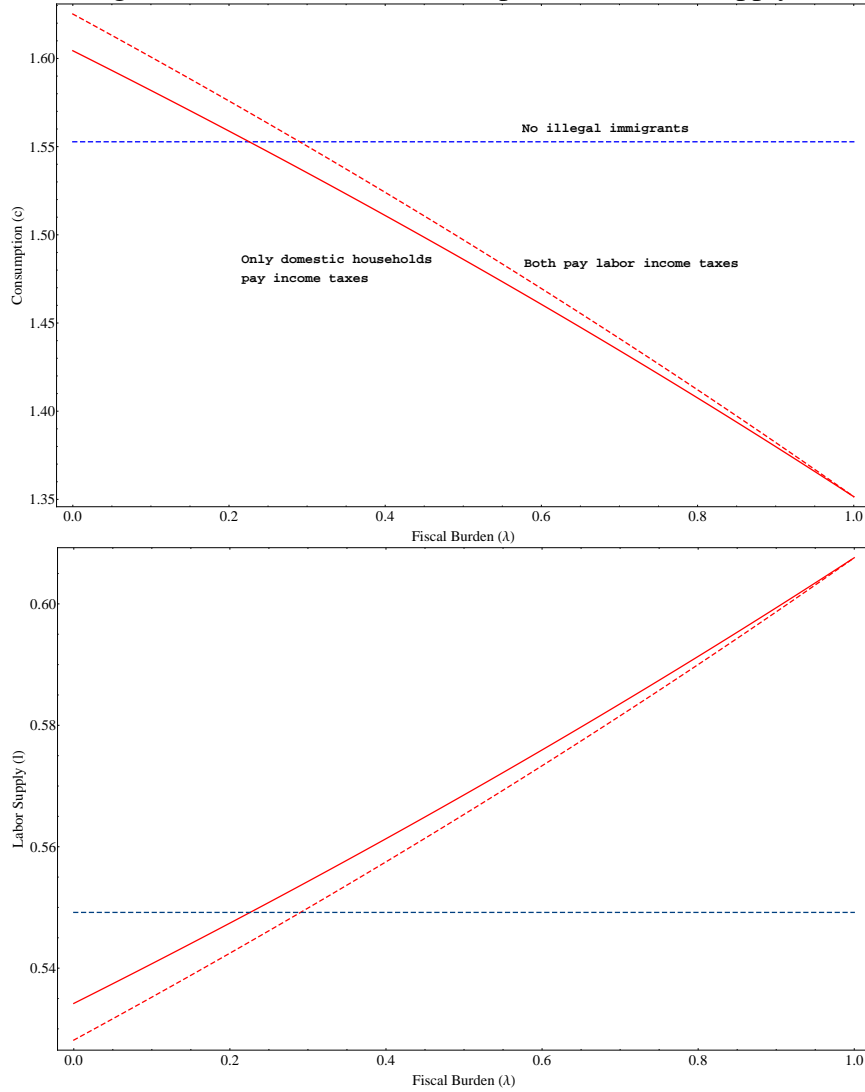
4.3 Discussion

In a decentralized competitive economy with fiscal policies including various taxations and income transfers, the presence of illegal immigrants in the domestic labor market generate mixed welfare results on domestic households. We recap the mechanism of fiscal policies on welfare effects in an endogenous domestic labor market. By paying a low wage to illegal immigrants, the producer earns a positive net profit from employing illegal immigrants, and thus domestic households increase income from the positive dividends from the producer. Then, domestic households increase their consumption, leisure, and capital accumulation. On the other hand, when illegal immigrants receive income transfers, the fiscal burden harms domestic households due not only to the negative income effect but also the distortionary effect on domestic households and the producer in a decentralized competitive economy. However, when illegal immigrants also contribute some of the government's tax revenue, its effect unambiguously improves domestic households' welfare. Hence, the net welfare effect of illegal immigration on domestic households depends on the mixed effects of the fiscal policies: the various taxes, income transfers, and fiscal burden. At a low level of the fiscal burden, domestic households are most likely to benefit from employing illegal immigrants due to the prevailing positive welfare effect from the wage difference in illegal immigration; otherwise, they can be harmed in the presence of illegal immigration.

Figure 1 illustrates how the degree of fiscal burden on domestic households affects the steady state consumption and labor supply per domestic household. For reference, the horizontal lines indicate consumption and labor supply with no illegal immigration. The solid red lines indicate consumption and labor supply when domestic households but not illegal immigrants pay a labor income tax. The dashed red lines indicate consumption and labor supply when both domestic households and illegal immigrants pay a labor income tax.²⁸ The solid red line intersects the horizontal lines at point A with a low degree of the fiscal burden, and the dashed red line intersects the horizontal lines at point B with a high degree of the fiscal burden. Therefore, up to point A, domestic households enjoy welfare improvement. However, beyond point B of the degree of fiscal burden, domestic households enjoy less consumption and leisure, regardless the tax contribution by illegal immigrants. Hence, domestic households are worse off in the presence of illegal immigration. In the interval between point A and B, the welfare effects on domestic households depend on the net amounts of their fiscal burden and the tax contribution by illegal immigrants.

²⁸Note that we consider an identical tax rate for both domestic households and illegal immigrants.

Figure 1: Fiscal burden, consumption, and labor supply



Note: $\alpha = 0.33$, $\beta = 0.67$, $\tau_l = 0.4$, $\varphi = 0.05$, $\theta = 0.33$, $\mu = 0.5$, and $\rho = 0.04$ in (47), (49), (57), and (59). The solid blue line is a baseline with no illegal immigration $\varphi = 0$. The solid red lines stand for consumption and labor supply when only domestic households pay the labor income tax. The dashed red lines indicate consumption and labor supply when both domestic households and illegal immigrants pay a labor income tax.

5 Concluding remarks

We explore the welfare effect of illegal immigration by incorporating an elastic labor supply and governmental fiscal policy in a dynamic general equilibrium model. The elastic labor supply allows domestic workers to optimally adjust their labor-leisure choices in response to illegal immigrants in the domestic labor market. Allowing labor-leisure choices creates a channel for the positive welfare effect on domestic households in the presence of illegal immigration. This channel has not been addressed in the existing literature and has thus induced a biased assessment on the gain of employing illegal immigrants in a dynamic competitive economy. Although causing labor market competition with domestic workers, illegal immigrants generates a positive welfare effect as long as the producer hires illegal immigrants at a lower wage compared to that of the domestic workers. Then, domestic households enjoy more consumption and leisure via more capital accumulation in the long run.

We then extend the dynamic laissez-faire economy to a decentralized competitive economy with fiscal policies. We show that the effects of income and capital taxes with endogenous labor-leisure choices exceeds the expected effects of taxation in competitive economy with illegal immigration. However, the effect of the payroll tax is ambiguous on the welfare of the domestic economy. Furthermore, we demonstrate the equivalence theorem in tax incidence of various taxes and income transfers so that the properties of illegal immigration are robust in a decentralized competitive economy. We then show that the equivalence theorem no longer prevails in the tax incidence of labor taxes in a domestic labor market. That is, the impact of the labor tax imposed on the demand for labor is not equal to that on the supply of the labor in the domestic labor market with illegal immigrants. In addition, fiscal burden is a critical source to generate a negative welfare effect of illegal immigration by which domestic households are harmed by the negative income and distortionary effect. This findings justify the public debate on how the fiscal burden or drain determines the domestic household's welfare, along with the revenue contribution in the presence of illegal immigrants.

We conclude by discussing a few limitations and potential extensions of our illegal immigration model. First, a future study may relax some of the assumptions on illegal immigration, for example, a fixed number of illegal immigrants and an exogenous wage difference between domestic workers and illegal immigrant workers. Then, we may extend our closed economy to a two-country open economies to endogenize the labor supply of illegal immigrants. Second, we may consider that government policies are efficiently chosen in a decentralized competitive economy with illegal immigration. We then solve a social planner's problem for an optimal taxation and income transfers in the presence of illegal immigrants. Finally, we may consider

the other types of governmental policies such as border control and internal enforcement for illegal immigration. We leave all of these avenues for the future research.

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