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Article

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An investigation on immigration inflows, GDP productivity and knowledge production in selected OECD countries: A panel model analysis

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Abstract

Purpose – The purpose of this study is to investigate the impact of pervasive immigrant inflows on GDP productivity growth in selected OECD countries, including Australia, Canada, Germany, Italy, New Zealand and the USA. The study aims to consider patent filing residence and non-residence as well as R&D expenditure to see if large immigrant destination countries can accept many immigrants to generate knowledge and creativity and stimulate economic development.

Design/methodology/approach – The study uses OECD and WDI data sets from 2000 to 2019 and employs a fundamental correlation matrix and static panel model to analyze the data. The study examines the impact of residential and non-residential patent applications and R&D expenditure on GDP productivity growth in the selected OECD countries.

Findings – The study found an adverse effect for residential patent applications, while non-residential patent application and R&D expenditure variables were strongly linked to GDP productivity. This indicates that to reap the benefits of skilled immigration inflows, the selected OECD countries must devote more resources to research and development and build a knowledge-based economy. This will improve economic efficiency and overall growth.

Originality/value – This paper assists policymakers in comprehending how to effectively utilize immigration inflows in developed and emerging economies in order to construct a future knowledge-based economic system.

Keywords Immigration inflows, Knowledge production, R&D, Patent, GDP

Paper type Research paper

1. Introduction and research problem

According to the theory of endogenous growth models, a greater population size (of skilled workers or immigrants) could increase the economy's growth rate in general (Jones, 1995). The aim of this paper is to look at the impact of immigrant inflows on the growth of factor productivity in the host country by looking at the effects on GDP productivity, R&D expenditure and patent applications. In selected OECD countries, such as Australia, Canada, Italy, New Zealand, Germany and the USA, we can see a clear positive relationship between



JEL Classification — F0, F2

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permanent immigration flows, GDP per hour employed, R&D expenditure as a percentage of GDP and patent application in host countries by using a simple correlation and static panel model. Permanent inflows of skilled immigrants are thought to boost these countries' growth. What we are curious about is how much of the knowledge or innovation production of these selected countries is caused by skilled worker immigration in the host country border, which we calculate in terms of patent applications by residence and non-residence.

It was shocking to learn from OECD and WDI data sources that Australia had 27,102 non-residence patent applications in 2019 (see [Appendix, Figure A1](#)), compared to 20,802 in Germany and 898 in Italy in the same year. This indicates that, unlike Germany and Italy, the climate for innovation and knowledge production is better outside Australia than within the country. To back up this intriguing discovery, we looked at both countries' R&D spending and discovered that Australia spends only 1.87% of GDP on R&D, while Germany spends 3.03%. A better research environment will aid in producing more knowledge, like in Germany, rather than simply growing immigration volumes to improve R&D lead growth, as in the case of Australia. This study strongly believes that research into this phenomenon is worthwhile to provide policy guidance to major immigrant-receiving countries such as the larger OECD member states.

1.1 Brief literature review and gap in existing literature

For decades, there has been heated debate about the intricate relationship between immigration, economic growth and knowledge generation. Understanding these complex relationships is especially important in the context of high-income economies, such as those in the Organization for Economic Cooperation and Development (OECD). While substantial study has been conducted on components of this nexus, critical gaps remain, limiting our comprehension of the whole and nuanced picture. This study seeks to fill these gaps by using a thorough panel model analysis to examine the combined impact of immigrant inflows, GDP productivity and knowledge production on economic growth in selected OECD nations.

A large body of research has been conducted on the relationship between immigration and economic growth, generating a variety of results. Early studies, such as [Borjas \(1995\)](#) and [Jones \(1995\)](#), frequently focused on the possible negative effects of low-skilled immigration on native wages and employment, resulting in heated disputes. However, later research, such as [Peri \(2014\)](#) and [Felbermayr *et al.* \(2012\)](#), present a more complex picture, indicating a positive, although slight, relationship between high-skilled immigration and per capita GDP growth. Notably, [Beine *et al.* \(2011\)](#) emphasize the dynamic nature of these impacts, indicating how initial skill inequalities between immigrants and native populations tend to disappear over time, eventually contributing to increased productivity.

The impact of immigration on economic development is a crucial determinant in assessing the advantages it brings to the host community ([Orefice, 2010a, b](#)). If the rate of per-capita income growth increases due to immigrants, it is likely that the overall standard of living of the general population will also increase. The Solow–Swan model posits that the main catalysts for growth in advanced economies, such as those in the OECD, are innovation and the ongoing generation of information ([Boubtane *et al.*, 2016a, b](#)). While extensive research has explored the labor market and fiscal consequences of immigration, the literature on its impact on per-capita growth is relatively limited ([Felbermayr *et al.*, 2012](#); [Manole and Schiff, 2013](#)). Varied outcomes are observed, and comparisons are hindered by differences in methodology, nation samples and time durations employed in prior studies ([Naudé and Nagler, 2018a, b](#); [Orefice, 2010a, b](#); [Rother, 2017](#)).

The present study aims to investigate the correlation between labor productivity and economic growth in a sample of seven OECD countries throughout the period of 2008–2014, employing panel data analysis. A unidirectional causality link is identified, wherein economic

expansion is seen to have a significant impact on labor productivity (Tufail *et al.*, 2023). The enhancement of labor productivity plays a crucial role in fostering economic growth. The implementation of this strategy results in a decrease in input expenses and facilitates the optimal utilization of production resources. Developed nations have elevated levels of labor productivity as a result of robust economic, educational and healthcare systems, alongside advancements in technology. The enhancement of labor productivity is significantly influenced by technological breakthroughs and the engagement in research and development endeavors. In order to attain technical advancements and enhance production, it is imperative for nations to allocate greater investments in these domains. The results of the study provide empirical evidence that there is a positive correlation between economic development and labor productivity in countries. According to Tufail *et al.* (2023), a significant correlation exists between labor productivity and economic growth in the long run.

The migration of highly qualified workers has the potential to attract foreign direct investment, aid in the identification of investment opportunities for enterprises in international markets and increase per capita income by driving productivity. Immigrants with a college education are more likely to have a significant impact on foreign direct investment and participate in research and development activities than their low-skilled peers. Immigrants working in science and technical industries are expected to have the greatest productivity benefits. However, immigration causes an increase in housing expenses, which has significant ramifications for income distribution. Unfortunately, the impact of increased immigration on residential investment is insufficient to fully offset the rise in housing costs. This complex relationship between immigration and housing costs highlights the multifaceted issues of population mobility and its impact on economic dynamics. The immigration of individuals with low skills does not have a significant impact on patenting activities. The skill acquisition process of migrants has the potential to impact labor productivity within the nations they migrate to. According to a study conducted by researchers from the University of Fribourg in Switzerland and the Institute of Labor Economics in Germany, immigrants, especially those with high levels of skills, play a crucial role in enabling cross-border financial flows in situations where there are significant informational challenges (Grossmann, 2021).

Germany has exhibited significant integration into the international community of researchers, establishing robust connections with the USA, the United Kingdom and Switzerland. However, it has observed a trend of dispatching a greater number of researchers for publication purposes overseas, as opposed to attracting researchers from other countries. This implies that Germany should prioritize the development of tactics aimed at attracting and retaining international scholars who demonstrate exceptional citation performance. The examination of compositional differences in migration flows has the potential to mitigate enduring gender disparities in specific domains. This suggests that it is imperative to undertake endeavors aimed at comprehending and mitigating the gender discrepancies observed in migratory trends, in order to guarantee equitable possibilities for researchers across various fields of study. Researchers who relocate to Germany demonstrate greater annual citation rates in comparison to researchers who do not relocate, suggesting that their scientific contributions are noteworthy. This underscores the significance of academic mobility in relation to the generation of knowledge and its subsequent influence. Among scholars who are internationally mobile, transients and return migrants have greater annual citation rates compared to immigrants and emigrants. According to [An introduction to the economics of immigration in OECD \(n.d.\)](#), it can be inferred that the intricacy of mobility trajectories potentially has a role in the augmentation of citation rates.

The Solow–Swan model provides a fundamental framework for explaining economic growth in industrialized economies such as the OECD (Boubtane *et al.*, 2016a, b). This paradigm contends that technological improvements and knowledge development, coupled

with physical capital accumulation, are the fundamental drivers of long-term economic growth. Empirical research such as [Jones \(2002\)](#) and [Romer \(1994\)](#) give more evidence of this positive relationship, emphasizing the importance of innovation and knowledge spillovers in promoting economic growth. However, knowledge creation involves a broader idea that goes beyond technological discoveries and patent data. Research by [Keller \(2004\)](#) and [Bloom *et al.* \(2012\)](#) underlines the necessity of taking into account many types of information, such as scientific breakthroughs, cultural knowledge transfer and even entrepreneurial skill sets. This multimodal lens is critical for understanding immigrant communities' contributions, since they may contribute not just technical competence but also new cultural viewpoints and behaviors that promote innovation and diversification within host economies. The phenomenon of knowledge globalization has resulted in a diminished competitive advantage for the USA in high-tech and information-intensive sectors, as emerging nations increasingly possess the necessary resources to generate scientific and technical advancements. The science and engineering workforce in the USA are experiencing a growing presence of scientists and engineers who are immigrants, many of whom enter the country as international students. The involvement of Chinese scholars in collaborative efforts and the inclusion of immigrant researchers and students have emerged as essential factors in scientific endeavors within the USA. The USA possesses various advantages within the global knowledge economy, including a highly esteemed higher education system, a substantial research enterprise, a prosperous innovation system safeguarded by intellectual property rights and a business culture that fosters the establishment of start-up ventures. One potential concern for the USA is the possibility that countries with lower wages and labor costs could progressively generate a larger share of scientific and engineering-driven inventions. This could potentially diminish the comparative advantage that the USA currently holds in these domains ([d'Albis *et al.*, 2019](#)).

The formulation of policies that enable the USA to capitalize on the globalization of information, while concurrently mitigating potential risks, is imperative. Policies ought to prioritize the retention and attraction of highly skilled immigrant scientists and engineers, given their indispensable contribution to scientific endeavors within the USA. The promotion of collaboration with scholars from nations such as China is imperative, given that international collaborations play a vital role in driving scientific achievements in the USA. It is imperative for the USA to sustain its investments in the higher education system in order to effectively appeal to the most exceptional and talented students globally. The protection of intellectual property rights is crucial in order to sustain the efficacy of the innovation system in the USA. According to [Rana *et al.* \(2020a, b\)](#), it is imperative for policies to consider the potential risk posed by other nations with comparatively cheaper wages and labor costs, since they may increasingly dominate the production of science and engineering-based breakthroughs.

Highly skilled migrants exert a notable influence on technical innovation and research and development inside host countries, particularly those with high-income levels. Migrants and diaspora communities play a crucial role in facilitating the transfer of technology from host nations to their countries of origin. This transfer is accomplished through several means such as information exchange, remittances, investments and assistance in the establishment of enterprises and research institutes. The influence of technology, namely the utilization of mobile phones for digital connectivity, has a significant and far-reaching effect on migration. This impact is mostly observed through the provision of information accessibility, facilitation of remittance processes and the establishment of connections between migrants and their families. The administration of migration by the government is significantly dependent on the utilization of technology, encompassing both the regulation of migration flows and the subsequent processing of migrants once their arrival. Workplace diversity coming from immigrant employees adds favorably to creativity and innovation within teams and

businesses. The intersection of technology and migration plays a pivotal role in the attainment of many Sustainable Development Goals (SDGs). Policymakers in both destination and origin countries should recognize and leverage the potential of both migration and technology (Blit *et al.*, 2020; Miguelez and Noumedem Temgoua, 2020).

This study article provides valuable insights into the effects of immigration on both host and home countries through various significant avenues: The study demonstrates a favorable association between the influx of skilled immigrants, specifically those in the fields of science and engineering, and Foreign Direct Investment (FDI), innovation and labor productivity in the receiving nations. The aforementioned study offers empirical support for the notion that immigrant workers with high skill levels have the ability to attract foreign direct investment (FDI), identify investment prospects in foreign markets, foster innovation through patenting activities and increase per capita income by improving labor productivity. The findings suggest that the influence of immigration by low-skilled migrants on the capital formation of host countries is rather limited. This supports the idea of adopting a selective approach to immigration, prioritizing highly skilled individuals, particularly those with expertise in science, technology, engineering and mathematics (STEM) fields. This study emphasizes the positive impacts of birthplace diversity resulting from immigration, particularly when immigrants possess high levels of education, on the economic well-being of the receiving nations. The report additionally recognizes the phenomenon of brain drain, positing that immigration policies that prioritize skilled individuals may result in a net depletion of skills in developing nations. One potential measure to mitigate the consequences of brain drain is the provision of increased student visas for persons from developing nations, enabling them to pursue higher education in rich ones. From a developmental policy standpoint, the article emphasizes the significance of remittances from migrants, particularly those who are transitory, in relation to the economic advancement of their home nations. However, it is important to note that temporary migration may have a possible drawback, as highlighted by Schultz and Seele (2023). Specifically, temporary migrants may have reduced motivation to acquire proficiency in the language of the host nation, which could ultimately restrict their ability to earn higher incomes in the future.

The phenomenon of immigration exerts a favorable influence on the gross domestic product (GDP) per capita of the host country, while concurrently exhibiting an adverse effect on aggregate unemployment rates for both native-born and foreign-born individuals. Migration flows are influenced by the economic conditions of the host country, including factors such as GDP per capita and the overall unemployment rate. Enhanced economic conditions serve as a catalyst for augmenting migrants' motivations to engage in migration, while elevated levels of unemployment render countries comparatively less appealing to prospective migrants. Migratory policies have a significant impact on the formation and direction of migratory patterns. Governments often impose limitations on permanent residency permits in times of elevated unemployment rates, while improved economic circumstances might alleviate apprehensions regarding the influence of immigration on employment prospects for native-born individuals. The considerable proficiency exhibited by migrants in recent decades has been essential in fostering economic growth in host countries. There exists a favorable correlation between the level of education attained by migrants and the impact of immigration on the host country's economic growth. The utilization of immigration as a plausible remedy to address labor shortages in OECD nations is a topic worthy of consideration, as it does not appear to have detrimental effects on the job opportunities of both native and foreign-born inhabitants. Overall, the findings imply that immigration can add to host nation economic success and employment prospects, and immigration rules can be modified to labor market demands without worrying about a detrimental impact on growth and employment (Kim, 2019a, b).

A considerable body of research (Baltagi *et al.*, 2020; Huang *et al.*, 2023; Qabaja and Tenekeci, 2022) has examined the individual effects of immigration on GDP productivity. However, there exists a notable knowledge gap regarding the collective influence of immigration inflows, GDP productivity and knowledge production, particularly within OECD countries. Moreover, several comprehensive panel model evaluations have been undertaken, revealing a notable methodological deficiency in the existing body of literature. This study aims to address these knowledge gaps by providing new perspectives on the intricate interplay among these variables and use rigorous panel model analytic methods to assure the credibility of the findings.

Many previous research studies conclude with empirical findings, skipping the critical step of converting knowledge into practical policy suggestions. This research tries to address the gap by creating targeted policy solutions. Based on the empirical findings, specific strategies are proposed to maximize immigration's beneficial economic and knowledge-generating potential while limiting possible downsides such as brain drain and social disparities. Second, focus on knowledge transmission mechanisms. Recommend policies that encourage information sharing and collaboration between immigrant and native populations, such as language training programs, intercultural exchange efforts and immigrant entrepreneur mentoring programs. Third, examine context-specific concerns. Recognize that the best policy options would differ among OECD nations with varied economic structures, immigration profiles and social settings.

The supplied publications primarily focus on the theoretical framework that underlies the relationship between immigration, labor productivity, economic growth and knowledge production. The analysis specifically examines the effects of immigration on both host and home countries. Furthermore, this analysis also examines the impact of high-skilled immigrants, technology and innovation on the aforementioned processes. The following is a concise overview of the fundamental theoretical aspects and possible areas of research that have yet to be explored:

Firstly, labor Productivity and economic growth: The initial study establishes a unidirectional causality relationship from economic growth to labor productivity. It underscores the importance of labor productivity as a driver of economic growth, particularly in developed countries with strong economic, educational and health infrastructures.

Secondly, immigration and high-skilled workers: The writings highlight the positive impact of immigration by high-skilled workers on host countries. Such immigration is linked to attracting foreign direct investment (FDI), stimulating innovation and raising per capita income through increased labor productivity. Additionally, the role of immigrants in scientific and engineering fields is emphasized.

Thirdly, globalization of knowledge: The globalization of knowledge is changing the landscape of science and technology. The USA is experiencing a shift in its science and engineering workforce, with a growing reliance on immigrant scientists and engineers. Collaboration with other countries and the protection of intellectual property rights are critical factors in this context.

Fourthly, policy recommendations: The writings suggest several policy recommendations for host countries, including attracting and retaining talented immigrant scientists and engineers, promoting international collaborations and protecting intellectual property rights. They also emphasize the potential threat of other countries producing more science and engineering innovations due to lower labor costs.

Fifthly, technology-migration nexus: The role of technology in shaping migration patterns and government management of migration is acknowledged. It is also noted that workplace diversity resulting from immigrant employees can positively impact creativity and innovation.

Several theoretical frameworks offer perspectives on the possible link between immigration and knowledge development. Borjas and Ramey (1995) propose the "ethnic knowledge spillover" hypothesis, which states that immigrants can transmit knowledge specific to their communities (e.g. language, cultural practices) to native populations, thereby

increasing productivity and innovation in sectors such as services and creative industries. This information exchange can take place through official channels such as educational institutions or through informal encounters on social networks.

The “cultural diversity hypothesis” (Alesina and La Ferrara, 2002) holds that ethnic and cultural variety caused by immigration can stimulate creativity, tolerance and receptivity to new ideas, resulting in enhanced innovation and economic dynamism. This idea is supported by research such as Ottaviano and Peri (2012), who show favorable associations between cultural diversity and better rates of business entrance and innovation in certain industries. However, it is critical to recognize the possible drawbacks of excessive variety, such as social conflict or communication obstacles across varied civilizations, which can inhibit knowledge exchange and collaboration.

Finally, the “brain drain” phenomenon might counteract the favorable impacts of immigration on knowledge creation in sending nations. Beine *et al.* (2018), as well as Docquier and Rapoport (2012), underline the need of policy interventions that stimulate knowledge exchange and collaboration between sending and receiving nations in order to reduce brain drain and maximize migration advantages.

2. Variable name and data source

We have used panel data for our current study to investigate the dynamics of immigration, productivity and knowledge production. The dataset comes primarily from the selected Organization of Economic Co-operation and Development (OECD) countries, namely Australia, Canada, Italy, Germany, New Zealand and the USA. The years of our research cover 2000 to 2019. We chose these countries based on the availability of data and the fact that they have higher immigration inflows than other OECD countries. Data is gathered from the World Development Indicators (WDI Database Archives (beta) and the OECD Stats website-2022. The selection of the data period is determined by the availability of data in both data sets. Prior to 2000, a majority of the variables had missing data. Data for all nations is currently unavailable. Therefore, we have chosen the data from the period of 2000–2019 for this analysis. The variables mentioned below were used. The dependent variable is the GDP per hour worked in the host countries, a proxy for labor productivity per hour of production operation. The independent variables are immigration flows, R&D expenditure as a percentage of GDP and patent applications to residents and non-residence.

Literature supports the rationale for choosing these specific variables. Human capital concentration can be compensated in the augmented Solow-Swan model system (Mankiw *et al.*, 1992), where human capital often contributes to the production process if immigrants are expected to bring human capital with them. In this scenario, the secret to determining whether immigration positively affects per capita GDP production is whether immigrants carry enough human resources to compensate for the host country’s dilution. If immigrants have a low level of human resources, their effect on per capita GDP is close to that of a simply faster population growth. To quantify this phenomenon, this study used the GDP per workday and Permanent Immigration Inflows variables. Using a Cobb–Douglas constant return to scale technology, a previous researcher considers an economy in which production is generated with labor, human and physical resources (Mankiw *et al.*, 1992). The model includes immigration by changing the working population growth rate (including the net immigration rate) and assuming immigrants have some human capital, which changes the human capital accumulation equation. The authors conclude that immigration harms production and development in the host country. In contrast, higher levels of human capital owned by immigrants have a positive impact on both output and income growth rates.

Thus, to present this argument in our study, this research uses expenditure on research and development that induces productivity, such as ‘A’ in the Cobb–Douglas production

function, and applies Patent applications as productivity or innovation output in the economy. In our chosen countries, the literature suggests that highly qualified foreign-born individuals contribute significantly to the human resource endowments of regions in the USA, Canada and Australia in absolute numbers. However, due to a lack of separate data, we cannot use exact data on the qualified labor force across the OECD countries in this report. Higher H-1B admissions increase immigrant science and engineering (SE) jobs and patenting by inventors with Indian and Chinese names in cities and firms relying on the program compared to their peers, according to a survey. Not only the H-1B visa for skilled workers in the USA but also Canadian express entry, Australian skill subclass visa 189 and regional subclass skill visas 489 are examples of countries that only enable permanent immigrants to settle with a particular skill. As a result, in our research, we use immigrant inflows as a proxy for increased productivity in host countries when combined with expertise and innovation. One of the reasons we chose this variable is that our research uses cross-country balanced panel results. We look at two other variables from the same data source to see if they support this pattern. Individuals born outside of the USA and school enrollment as a percentage of total enrollment. The data show that foreign-born people raise the average level of education in host countries, with a positive upward trend (see [Appendix, Figure A2](#)). According to the numbers, this is the case in several OECD countries.

[Table 1](#) contains descriptions of the data and variables, and [Table 2](#) shows summary statistics of panel data.

2.1 Empirical methodology

Functional understanding of empirical methodology is as follows, let i represent a country, t represents time, Y_{it} represent its real gross domestic product (GDP), K_{it} represent its level of knowledge production, and I_{it} represent the level of immigration inflows into the country at time t . We can assume that immigration inflows have a potential effect on both GDP productivity and knowledge production, and that these effects may vary across countries and time periods, which can be expressed as:

$$Y_{it} = \alpha_{1it} + \beta_{1it}I_{it} + \gamma_{1it}X_{it} + \varepsilon_{1it}$$

$$K_{it} = \alpha_{2it} + \beta_{2it}I_{it} + \gamma_{2it}X_{it} + \varepsilon_{2it}$$

where X_{it} represents a vector of control variables that may influence GDP productivity and knowledge production, α_{1it} , α_{2it} , β_{1it} , β_{2it} , γ_{1it} and γ_{2it} are coefficients, and ε_{1it} and ε_{2it} are error terms that may be correlated across time within each country.

To account for potential differences across countries and time periods, we can estimate these equations using a panel data model that allows for both country-specific and time-specific effects:

$$Y_{it} = \alpha_{1it} + \beta_{1it}I_{it} + \gamma_{1it}X_{it} + \varphi_i + \tau_t + \vartheta_{1it}$$

$$K_{it} = \alpha_{2it} + \beta_{2it}I_{it} + \gamma_{2it}X_{it} + \varphi_i + \tau_t + \vartheta_{2it}$$

where φ_i and τ_t represent country-specific and time-specific effects, respectively, and ϑ_{1it} and ϑ_{2it} represent error terms that may be correlated across countries and time periods.

To estimate the coefficients and effects in these equations, we can use panel data regression techniques such as fixed effects or random effects estimation. These techniques allow us to control unobserved heterogeneity across countries and time periods, and to test for the statistical significance of the coefficients and effects. Therefore, at first, we begin the analysis of the relationship between the dependent and independent variables by using simple correlation matrix. [Table 3](#) shows the result of a simple correlation matrix.

Table 1.
Variable names and
Data Sources

SL.	Variable name	Description	Short form	Source data
1	GDP per hour worked	<i>GDP per hour worked is a measure of labor productivity. It measures how efficiently labor input is combined with other factors of production and used in the production process</i>	GDPHRWKD	OECD Data-2020
2	Permanent immigrant inflows	<i>Permanent immigrant inflows cover regulated movements of foreigners considered to be settling in the country from the perspective of the destination country. They cover regulated movements of foreigners as well as free movement migration</i>	IMMIGINFLOW	OECD Data-2020
3	Research and development expenditure (% of GDP)	<i>The gross domestic expenditure on R&D indicator consists of the total expenditure (current and capital) on R&D by all resident companies, research institutes, universities, government laboratories, etc. It excludes R&D expenditures financed by domestic firms but performed abroad</i>	R&DEXPERGDP	WDI-2020
4	Patent applications, non-residents	<i>Non-resident patent applications</i> are from applicants outside the relevant State or region	PATENTNONRE	WDI-2020
5	Patent applications, residents	<i>Resident patent applications</i> are those for which the first-named applicant or assignee is a <i>resident</i> of the State or region concerned	PATENTS	WDI-2020

Table 2.
Summary statistics of
panel data

Variable names	Max	Min	Mean	Median	Total observations
GDPHRWKD	103.80	78.71	94.98	96.84	703
IMMIGINFLOW	1,266,264	41,592	394,137	239,748	703
R&DEXPERGDP	3.101	1.006	1.938	1.882	703
PATENTNONRE	336,340	779	52,315	20,127	703
PATENTRESI	295,327	324	50,950	6,656	703
Source(s): Authors' calculations					

Table 3.
Correlation matrix

	GDPHRWKD	IMMIGINFLOW	R&DEXPERGDP	PATENTNONRE	PATENTRESI
GDPHRWKD	1	0.45	0.56	0.39	0.35
IMMIGINFLOW	0.15	1	0.63	0.81	0.85
R&DEXPERGDP	0.45	0.63	1	0.56	0.63
PATENTNONRE	0.0390	0.81	0.56	1	0.96
PATENTRESI	0.0158	0.85	0.63	0.96	1
Source(s): Authors' calculations					

From the correlation matrix, we have found that IMMIGINFLOW, R&DEXPERGDP, PATENTNONRE, PATENTRESI are moderately correlated with the dependent variable GDPHRWKD (GDP productivity per hour 2005 US\$). Thus, we are interested in pursuing an econometric model to check our theoretical understanding. The idea we're interested in is whether immigration boosts economic growth while also producing economically useful innovation in the form of patent production. We would also like to see the production climate conducive to increasing patent applications from the country. According to the new economic growth theory, steady-state economies can transition into an advanced economies by following an innovation-driven growth strategy. To foster creativity, the country also requires a well-trained workforce, along with increased investment in research and development.

The static panel model, thus,

$$\begin{aligned} \text{GDPHRWKD}_{it} = & \alpha + \beta 1 \text{IMMIGINFLOW}_{it} + \beta 2 \text{R\&DEXPERGDP}_{it} \\ & + \beta 3 \text{PATENTNONRE}_{it} + \beta 4 \text{PATENTRESI}_{it} + \varepsilon_{it} \end{aligned} \quad (1)$$

Equation (1) is a balanced panel model using four independent variables and one dependent variable. Here, *t* and *i* stand for cross-section and time series ID. In most cases, we can use one of three methods to analyze panel data: OLS, GLS, or WLS, to analyze linear panel models. We used the OLS method to estimate our case's panel linear regression equation. With non-experimental results, we could have used the Difference and Difference (DID) method to estimate treatment effects. DID's most useful function is this. Fixed effects prediction is often referred to as DID. Panel data is not needed for DID if the repeated cross-sections are taken from the same aggregate unit. DID can be applied to a broader range of data than traditional fixed effects models, which include panel data. Since we prefer panel analysis in our research, we will use the traditional static panel model in equation (1). However, unlike the simple linear least square process, a panel model requires some tweaking; for example, we must determine if fixed or random effect models are suitable for panel data analysis. We use the Hausman test for fixed and random effect model selection to pinpoint and significance levels of our variables after carefully performing fixed and random effect estimation. The fixed effect, random effect and Hausman test results are in Tables 4 and 5.

GDPHRWKD	Coef	Std. Err	t	P> t	[95% Conf. Interval]	
RDEXPERGDP	5.879668	2.442402	2.41	0.018	1.039401	10.71993
PATENTNONRE	0.0002141	0.0000738	2.90	0.005	0.0000677	0.0003604
PATENTRESI	-0.0001508	0.0001079	-1.40	0.165	-0.0003647	0.0000631
IMMIGINFLOW2	0.021667	0.0139086	1.56	0.122	-0.0058966	0.0492305
_cons	78.76022	5.496662	14.33	0.000	67.86713	89.65332

Source(s): Authors' calculations

Table 4.
Fixed effect model

GDPHRWKD	Coef	Std. Err	z	P> z	[95% Conf. Interval]	
RDEXPERGDP	3.553144	1.98311	1.79	0.073	-0.3336799	7.439968
PATENTNONRE	0.0002305	0.000041	5.63	0.000	0.0001503	0.0003108
PATENTRESI	-0.0002102	0.0000495	-4.25	0.000	-0.0003072	-0.0001133
IMMIGINFLOW2	0.0209879	0.0146849	1.43	0.153	-0.0077939	0.0497698
_cons	85.47872	4.051729	21.10	0.000	77.53748	93.41997

Source(s): Authors' calculations

Table 5.
Random effect model

2.1.1 Hausman test result. Test: Ho: difference in coefficients not systematic

$$\text{Prob} > \chi^2 = 0.0001$$

The Hausman test results show that the probability of the chi-sq is very significant (0.0001), which is less than a 5% level of significance. Therefore, we can reject the null hypothesis. Our null hypothesis is that the random effect model is appropriate, and the alternative is that the fixed effect model is appropriate to our analysis. Thus, by looking at the Hausman result, we apply a fixed effect panel analysis which is an appropriate test in this context. We also add an autocorrelation test and correct the serial correlation in the model for robust output. See (Appendix, Table A1).

3. Empirical results discussion

Table 2 shows the results of descriptive statistics for the variables from 2000 to 2019. All the series have consistent mean, standard deviation, maximum and minimum values, according to the descriptive statistics of this article. To test the degree of functional estimation in Table 4 fixed effect model, it was discovered that the dependent variable GDP per hour productivity has a positive relationship with all of the independent variables, as predicted, except with residence patent filing. Research and Development spending and non-resident patent filing are strongly linked to GDP per hour. We can see that a 1% rise in R&D spending would increase GDP productivity by 1.8% in the selected OECD countries, which is an interesting finding from this report.

Furthermore, a 1% rise in non-residence patent filing boosts the host countries' GDP productivity by nearly 0.5%. This can be accelerated if the host country offers more assistance to non-residents who want to file patent applications. Surprisingly, there is a negative relationship between residence patent applications and GDP productivity, as evidenced by the results. This is a concerning problem for the host nation because it encourages constructive immigration and does not result in a substantial increase in efficiency by generating awareness and creativity in the host country. If we look at the random effect model closely, we can see a nearly identical situation in which GDP productivity has a positive and meaningful relationship with R&D spending, non-residence patent filing and immigration flows. GDP per hour efficiency, on the other hand, has a negative and vital association with the filing of a residence patent. The random effect model also yielded this negative result. This means that increased immigration inflows do not guarantee efficiency unless the country first creates a favorable environment for knowledge production by increasing R&D spending, education quality, science and technology funding, and so on. Finally, we can infer from this study that GDP is more efficient for economic growth if immigration inflows build value in the host countries in terms of expertise and innovation. According to the literature, economists have defined product entry and exit as a primary mechanism through which innovation impacts economic development. We show how high-skill immigration affects commodity reallocation (entry and exit) at the firm level in this paper. We find that H-1B certification correlates with higher product reallocation and revenue growth when data on H-1B Labor Condition Applications (LCAs) is matched to retail scanner data on goods and firm characteristics. A 10% rise in H-1B jobs is correlated with a 2% increase in product reallocation rates, which is our indicator of innovation. These findings shed light on the economic implications of high-skill immigrant innovation in the USA, and our findings are potentially backed by other studies (An Immigrant Workforce Leads to Innovation; How Much Does Immigration Boost Innovation?) — (Hunt and Gauthier-Loiselle, 2009), which is a significant contribution to existing literature.

Our investigation digs into the complex link between immigration, knowledge output and economic development in a few OECD nations, providing new insights into the intricacies of this dynamic interaction. While the data provide a varied picture, a few essential characteristics emerge.

The Importance of Knowledge Production in Driving Economic Growth: The strong positive relationship between R&D investment and GDP productivity emphasizes the importance of scientific and technological developments in driving economic growth. This is consistent with the Solow–Swan model and current empirical research, emphasizing the significance of promoting an environment of innovation and discovery. Notably, non-resident patent filings are also strong predictors of economic development, implying that importing knowledge through foreign-born talent and collaborations can be just as effective as domestic knowledge generation.

Immigration's Modest Contribution to Productivity: While the positive coefficient for immigration inflows may not be statistically significant at the 5% level, it does indicate a possible, however minor, influence of immigration to economic growth. This conclusion contradicts studies that emphasize the detrimental effects of low-skilled immigration on native wages, necessitating more research into the diversity of immigrant talents and their diverse contributions across industries. Furthermore, the lagged impact of immigration implies that any advantages may take time to manifest, necessitating long-term perspectives in evaluating immigration policy.

The Enigma of Resident Patent Applications: The unexpectedly negative, albeit statistically insignificant, link between resident patent applications and GDP productivity warrants additional investigation. Potential reasons include the likelihood that not all patents result in economically viable breakthroughs, or that particular industries depend more largely on imported information than indigenous inventions. Examining various types of patents or sectoral data may give light on these issues.

4. Conclusions, contributions and limitations

We anticipate a positive association between immigrant inflows and the GDP per hour worked variable in this study. It is critical to examine the connection in this context, regardless of how good or bad the interaction appears in the panel. Similarly, the model's three independent variables are compared and analyzed. The purpose of this study is to look at the link between OECD countries' GDP productivity, immigration inflows, patent filing resident and non-residence and R&D investment. We presented an overview of neoclassical growth relationships in Cobb Douglas production feature type, using research and development and a knowledge-friendly economic climate, with the goal of demonstrating that increased immigration inflows under any skill subclass would improve GDP productivity through R&D. Our findings are supported by analyses (Orefice, 2010a, b) ([High-skilled immigration increases innovation. The Hamilton Project, n.d.](#); [Hunt and Gauthier-Loiselle, 2009](#)). We began our inquiry with a correlation test, followed by a static panel data analysis. Panel research provides an intriguing outcome for OECD policymakers developing immigration policies to boost economic development. Our findings suggest that OECD countries should place a greater emphasis on building an atmosphere conducive to innovation in their host economies rather than simply attracting immigrants before the host country is ready to produce expertise to improve economic growth and productivity ([Apple, 2023](#); [Tufail et al., 2023](#)).

Immigration inflows have a positive, albeit slight, impact on GDP productivity per hour. In the fixed-effects model, the coefficient for immigrant inflow is not statistically significant at the 5% level, but the positive sign shows that immigration may contribute to economic growth. Increased R&D investment and non-resident patent filings are statistically significant predictors of increased GDP productivity. This study lends credence to the idea that knowledge generation is critical to promoting economic progress. Resident patent applications appear to have a detrimental, but non-significant, impact on GDP productivity. This surprising conclusion necessitates more examination, maybe using several types of patents or sectoral data.

This study adds to the current literature by using a panel data model to examine the joint impacts of immigration, knowledge output and GDP productivity in OECD nations. The research takes into account both delayed and current immigrant inflows, as well as several metrics of knowledge output such as R&D investment and patent applications. The findings offer empirical evidence for the relevance of knowledge generation in driving economic growth, emphasizing the potential impact of both local and international knowledge flows.

The study's concentration on aggregate data at the national level limits its capacity to investigate individual sectors or geographical differences in the links between immigration, knowledge production and economic growth. The measurements of knowledge production utilized may not completely represent the many kinds of information transfer and innovation made possible by immigration. The causal correlations between the variables deserve more exploration because the study is based on observational data and cannot completely account for any confounding variables.

Future studies should investigate the specific processes by which immigration and knowledge generation affect economic growth. Data disaggregation by industry, skill level and kind of knowledge may give more in-depth insights. In addition, this study explores the long-term effects of immigration, its impact on policy measures, and the effectiveness of strategies aimed at optimizing immigration and knowledge generation.

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Appendix

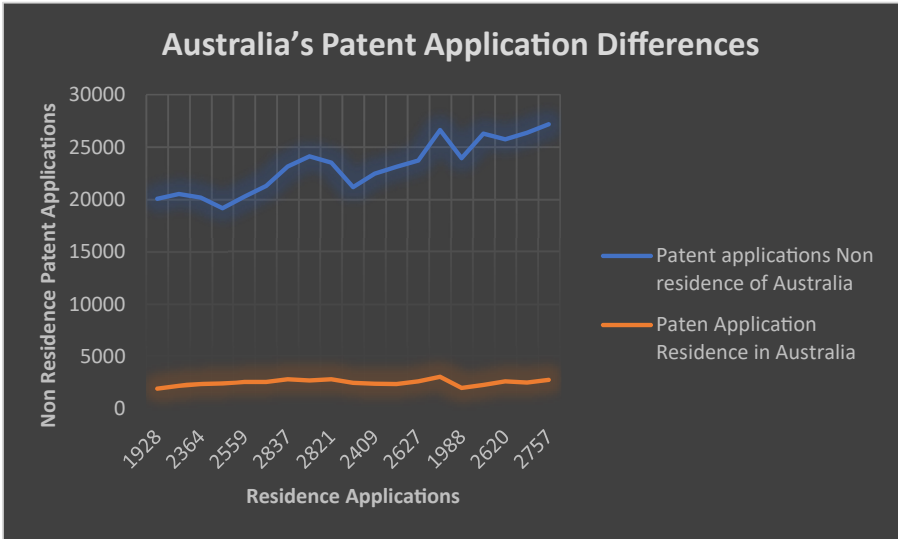
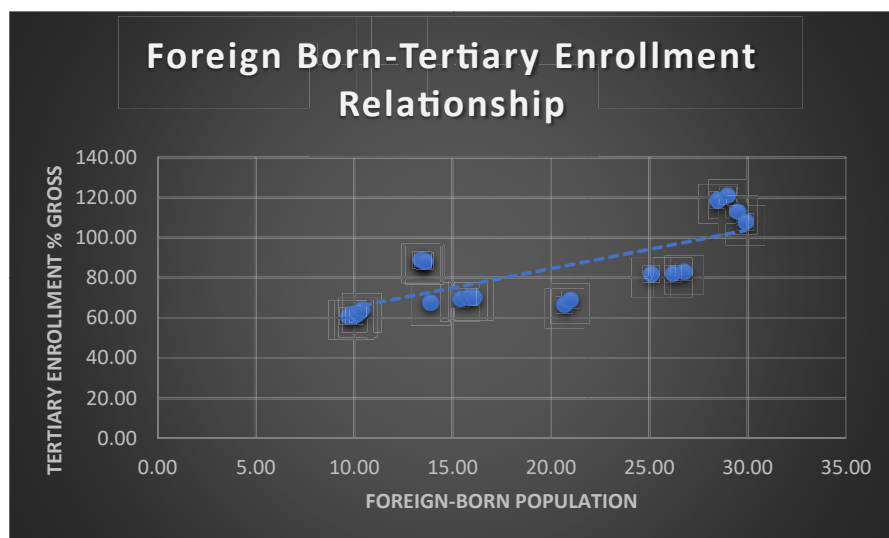


Figure A1.
The difference in residence and non-residence patent applications in Australia

Source(s): OECD and WDI database 2020



Source(s): OECD and WDI database 2020

Figure A2.
Foreign born
individual immigrants
and tertiary enrollment
% of total gross

GDPHRWKD	Coef	t	P> t
RDEXPERGDP	0.1900232	1.001222	0.025
PATENTNONRE	0.0000269	0.0000424	0.027
PATENTRESI	-0.0000222	0.000475	0.641
IMMIGINFLOW2	0.0109019	0.0228451	0.634

Note(s): Maximum lag: 3

Prob > F = 0.0291

Source(s): Authors' calculations

Table A1.
Regression with
Newey–West Standard
Errors

One can apply Newey–West variance on panel data in a context in which one is ready to assume independence in the cross section, however one wants to guard against heteroskedasticity and autocorrelation in the time series dimension as well. In this study, we have applied this new method for producing robust results. It works the same way as it works for time series data, except that now you have multiple time series, one time series for each cross-sectional unit. And again, we are assuming that the multiple time series are not correlated with each other.

These results are in line with our fixed effect findings without autocorrelation and heteroskedasticity. This is a corrected estimation with newly developed model and results support our hypothesis as well.

Word Cloud of Selected Papers in thematic analysis showing the concentration of mostly use words in the selected papers.

Author's name	Title	Result	Published year
Ekrame Boubtane, Jean-Christophe Dumont	Immigration and economic growth in the OECD countries 1986–2006: A panel data analysis	Both theses report positive relationships between GDP productivity and certain factors. For example, in my thesis, there's a positive relationship between GDP per hour productivity and R&D spending. Similarly, in the second thesis, the human capital contribution of foreign-born migrants has a positive and significant effect on productivity growth	25.07.2010
<ul style="list-style-type: none">Jaime Oliver HuidobroAlberto AntonioniFrancesca LipariIgnacio Tamarit	Social capital as a network measure provides new insights on economic growth	<ul style="list-style-type: none">Your thesis finds positive relationships between GDP per hour productivity and R&D spending, non-residence patent filing, and immigration flows. There's a negative relationship with residence patent filingThe second thesis indicates statistical significance for most social capital proxies, supporting the hypothesis that social capital factors drive GDP through productivity	26.08.2022
Anthony Edo Lionel Ragot Hillel Rapoport Sulin Sardoschau Andreas Steinmayr Arthur Sweetman Hande Aksoz Yilmaz Ahmet Incekara	An Introduction to the Economics of Immigration in OECD Countries An Analysis of the Dynamic Panel Gravity Model: effects of Immigration Flows from Turkey to OECD Countries on Foreign Trade	there are similarities, the specific findings and methodologies vary between the two theses Partially Same	SEPTEMBER 2020 5.08.2021
Elsadig Musa Ahmed	Are the FDI inflow spillover effects on Malaysia's economic growth input driven?	Both are not same subject	18.05.2012
Elsadig Musa Ahmed, Geeta Krishnasamy	Are Asian technology gaps due to human capital quality differences?	Both are different	1307.2013

Table A2.
Additional literature
review

(continued)

Table A2.

Author's name	Title	Result	Published year
Elsadig Musa Ahmed	Modeling green productivity spillover effects on sustainability	While both theses touch upon economic growth and productivity, they focus on different aspects. Thesis 1 delves into the empirical results of specific variables, including the impact of R&D spending and patent filing on GDP productivity, with a particular emphasis on the role of immigration. Thesis 2, on the other hand, broadly discusses the sustainability of higher economic growth through productivity, integrating environmental and social dimensions	31.03.2020
Prof. Elsadig Musa Ahmed	COVID-19 implications on IsDB member countries sustainable digital economies	while both theses touch upon economic growth, they differ in focus and variables considered. Thesis 1 examines traditional economic factors in OECD countries, while Thesis 2 explores the broader impact of digital technology in IsDB MCs and proposes a digital transformation program. There is no direct overlap in their findings, as their scopes and contexts are distinct	01.02.2020
Elsadig Musa Ahmed	Are Bio-economy Dimensions a New Stream Of The Knowledge Economy?	one potential point of connection might be the emphasis on research and development (R&D) in both theses. My thesis highlights the positive relationship between R&D spending and GDP productivity, while the second thesis mentions the centrality of R&D collaborations in the context of bio-economy	03.04.2018

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